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Check List of the Internal and External Animal Parasites of Domestic Animals in North America

(United States and Possessions, and Canada)

G. DIKMANS, D.V.M.
Washington, D. C.

THE COMMITTEE on Parasitology of the American Veterinary Medical Association, in its annual report for 1943 (J.A.V.M.A., *103*, (Nov., 1943) :331) recommended "That the Bureau of Animal Industry of the United States Department of Agriculture be requested to publish either a bulletin or a series of bulletins containing the following information: (1) check-list of parasites of domestic animals occurring in the United States indicating states in which each occurs, (2) indications by states as to which parasites are most prevalent and which are most serious, (3) species of animals which act as hosts, (4) locations of parasites in hosts, (5) intermediate hosts, if any, (6) keys for identification, and (7) descriptions." Some time later the executive secretary of the Association asked the Bureau whether it could prepare such a bulletin or series of bulletins. Unfortunately the Bureau is unable, at the present time, to comply completely with this request, since such compliance would involve, for all practical purposes, the writing of a textbook on the animal parasites of domestic animals in the United States. The Bureau, however, has agreed to the publication of the following check list in compliance with parts 1, 3, 4, and 5 of the Committee's recommendation. Compliance with parts 6 and 7, which would require a considerable amount of time on the part of several individuals, must be postponed until a more favorable time. The information given in column 5 of the check list is an attempt to comply with part 2 of the Committee's recommendation. It is the most difficult and will, undoubtedly, be found to be the most unsatisfactory part of the check list. Accurate information on the distribution of animal parasites within the several states in the Union and thus within the United States is still decidedly incomplete. In this connection, it may be of interest to quote a few lines from a paper published by the late Dr. M. C. Hall in the twenty-seventh annual report of the Bureau of Animal Industry in 1910. At that time, Dr. Hall wrote as follows: "It is impossible at the present time for anyone, even though in close touch with the parasite work in this country, to say out of hand whether a given parasite occurs in a given state, or to give the range of a parasite, or name the parasite fauna of a state, even for parasites of considerable importance." While progress has been made in the thirty-five years since these quoted statements were written, Dr. Hall's main contention that we do not have sufficient, accurate information concerning the occurrence, distribution, and relative importance of parasites in any given locality, is as true today as it was in 1910.

The information given in column 5 of the present check list is based in part on fact and in part on general information and assumption. The factual information was obtained from (1) the host-parasite catalogue, (2) the author-subject catalogue, (3) the U. S. National Museum Helmintho-

Dr. Dikmans is parasitologist in the Zoölogical Division, Bureau of Animal Industry, Agricultural Research Administration, U.S.D.A.

logical Collection, all maintained by the Zoölogical Division of the Bureau of Animal Industry, and (4) the papers cited in the list of references. The assumptions are indicated chiefly by the phrase, "Generally distributed throughout North America" occurring in many places in the column. These assumptions may or may not be correct but our information is to the effect that they are valid even though their validity cannot be immediately proved. The most reliable sources of information are undoubtedly the catalogues mentioned and the original papers cited but, even in the catalogues, one finds unverified references, and in original papers authors occasionally fail to mention specific hosts or specific localities from which parasites mentioned in the paper are collected. Information obtained from the U. S. National Museum Helminthological Collection is definitely informative as to both hosts and localities from which parasites are collected in the majority of instances, but in many cases the locality in which a parasite is collected is not the locality in which it occurs naturally. For example there are in the collection specimens of bots, *Gastrophilus intestinalis*, a normal parasite of the horse, taken from the stomachs of hogs at Chicago, Ill.; Omaha, Neb.; Sioux Falls, S. D., and Pueblo, Colo. From the information accompanying the specimens, it is quite clear that they were collected on postmortem examination of viscera at abattoirs having federal inspection. Obviously, the places at which these parasites were collected furnish no clue as to the localities in which the animals acquired these parasites. Another example that may be cited with profit is abattoir reports of liver fluke infestation in cattle outside of the normal range of distribution of this parasite. Whenever such animals can be traced, it is found that they originated in typical, liver-fluke infested areas. Some years ago, the writer's attention was called to a liver-fluke infestation in some cattle in western Maryland. Concern was expressed over the fact that a serious parasitic condition had remained unnoticed. Inquiry developed that the animals had been purchased as feeders at St. Joseph, Mo. There the trail was lost, but it is not unreasonable to suppose that the trail ran back directly to the Gulf Coast area of Texas. A map purporting to indicate the distribution of the liver fluke in the United States and based upon abattoir reports of the finding of these parasites on postmortem examination would be completely inaccurate and misleading.

A word of explanation should perhaps be offered in connection with the indicated distribution of the nematode parasites of horses, mules, and asses. There are comparatively few complete records of the nematode fauna of these animals in any one locality. This is undoubtedly due to the fact that it requires an enormous amount of work to collect and properly to identify all the nematodes found in a single animal. The contents of the intestinal tract of a horse fill a couple of ordinary washtubs and to wash and screen such an amount of material is a task before which the heart of even an enthusiastic parasitologist may well quail. Probably, not all of the nematodes listed occur in all parts of North America, but if 12 farm horses were examined in each of the states in the United States and a proportionate number in each of the provinces of Canada, all the nematodes listed would probably be found in every state distributed among the animals examined and some new ones might even be discovered.

With reference to the distribution of scab or mange mites, we have an impression that the skin diseases caused by the various mites are widespread and common, but when the U. S. National Museum Helminthological Collection is examined one finds that these parasites are represented by only very few entries. There are two possible explanations for this; namely, (1) that the parasites are not as common as they are generally believed to be, and (2) that they are so common that no one takes the trouble to collect them and record their presence. Whatever explanation is adopted, one runs into difficulty in attempting to indicate the geographical distribution of these parasites. A striking example of this difficulty is furnished by the reports of the presence of sarcoptic or head scab, caused by *Sarcoptes scabiei*, in sheep in the United States. While it is reported as not being

common in the United States, the reader is left to infer that it does occur. An examination of the host-parasite catalogue shows that there are no specific reports of its occurrence in any definite locality in the United States and an examination of the U. S. National Museum Helminthological Collection fails to reveal the presence of any specimens of *S. scabiei* collected from sheep. This, of course, may simply be another instance in which recognition is more rare than occurrence, as noted by Durant for demodectic mange in goats, but since the reports of sarcoptic scab in sheep are vague, indefinite, and unsubstantiated, I have omitted it from the list of external parasites of sheep and goats in North America, thereby resolving the problem of indicating its geographical distribution.

The information concerning the hosts and geographical distribution of various species of ticks was obtained from the U. S. Department of Agriculture, Bureau of Entomology Bulletin 106, entitled, "The Life History and Bionomics of Some North American Ticks," and from the publications by Cooley and Kohls, cited in the list of references.

In some cases, individual states and other limited areas are listed as areas of distribution for certain parasites. This does not mean that the areas mentioned comprise the range of distribution of these parasites. It simply means that, so far as I know now, the particular parasite has been reported from the host under which it is listed, only from that particular area.

In indicating the distribution of some parasites by groups of states, such as North Atlantic, North Central, etc., the division of the 48 states into five groups; namely, North Atlantic, North Central, South Atlantic, South Central, and Western, found in a publication of the former Agricultural Marketing Service, entitled, "Livestock, Meats, and Wool Market Statistics and Related Data," 1939, has been followed. The states included in each of these divisions are:

NORTH ATLANTIC	NORTH CENTRAL	SOUTH ATLANTIC	SOUTH CENTRAL	WESTERN
Maine	Illinois	Delaware	Alabama	Arizona
New Hampshire	Indiana	Florida	Arkansas	California
Vermont	Iowa	Georgia	Kentucky	Colorado
Connecticut	Kansas	Maryland	Louisiana	Idaho
Massachusetts	Michigan	North Carolina	Mississippi	Montana
New Jersey	Minnesota	South Carolina	Oklahoma	Nevada
New York	Missouri	Virginia	Tennessee	New Mexico
Pennsylvania	Nebraska	West Virginia	Texas	Oregon
Rhode Island	North Dakota			Utah
	Ohio			Washington
	South Dakota			Wyoming
	Wisconsin			

It is hoped that the present check list will stimulate all those who have knowledge of the occurrence of parasites in domestic animals, wherever in North America they or the animals may be located and regardless of whether the parasites and their distribution are included in the present list, to send their information to the Zoölogical Division, Bureau of Animal Industry, Beltsville Research Center, Beltsville, Md.

Various members of the Zoölogical Division contributed to the present list: Dr. E. W. Price checked the names of the parasites of dogs and cats and, in addition, he checked the names of all the trematodes; Dr. E. E. Wehr is responsible for the parasites of birds; Dr. L. A. Spindler for those of swine; and Dr. A. O. Foster for those of horses and for all the parasites of domestic animals reported from Panama; Drs. D. C. Boughton and J. C. Lotze checked the names of, and the information concerning, the protozoa.

The Canadian records have been checked by Dr. W. E. Swales, Institute of Parasitology, MacDonald College, McGill University, Quebec. The external parasites of all the groups of animals have been checked by Dr. W. E. Dove and Dr. H. E. Ewing, Bureau of Entomology and Plant Quarantine, Washington, D. C., and Dr. J. E. Ackert, Kansas State College, Manhattan, to whom the list was submitted for criticism, checked the names of the intermediate hosts of poultry tapeworms. Their aid is gratefully acknowledged.

(*See pages* 240-241 *for bibliography.*)

Check List of Animal Parasites of Domestic Animals in North America (United States and Possessions, and Canada)

TABLE 1.—HORSES, MULES, AND ASSES—INTERNAL PARASITES

GROUP AND COMMON NAMES	SCIENTIFIC NAMES	LOCATION IN HOST	INTERMEDIATE HOST	GEOGRAPHICAL DISTRIBUTION
Protozoa				
AMEBAE	*Endamoeba gedoelsti*	Intestine	.....	Iowa.
FLAGELLATES Trypanosomes	*Trypanosoma equiperdum*	Blood (rarely) Dourine plaques and edematous swellings about the genitals	Unknown	Western United States.
	T. venezuelense (*T. hippicum*)	Blood (rarely)	Vampire bat, *Desmodus rotundus murinus*, Tabanids or horse-flies probable mechanical vectors	Panama (Canal Zone).
SPOROZOA Haemosporidia	*Babesia caballi*	Blood	Ticks, *Boophilus annulatus* var. *microplus*	Panama (Canal Zone).
ORGANISMS OF UNCERTAIN ZOOLOGICAL CLASSIFICATION	*Sarcocystis* sp.	Muscles	Unknown	Ohio.
Trematodes (Flukes)				
LIVER FLUKE	*Fasciola gigantica*	Liver	Snails, *Fossaria ollula*	Hawaii.
Cestodes (Tapeworms)				
LARGE HORSE TAPEWORM	*Anoplocephala magna*	Small intestine	Unknown	New York, Virginia, Illinois, Iowa, Minnesota, and Montana.
MEDIUM HORSE TAPEWORM	*A. perfoliata*	Cecum	Unknown	Pennsylvania, Ohio, Michigan, Washington, British Columbia, Puerto Rico, Virgin Islands, Panama (Canal Zone), Hawaii, Canada (Ontario).
DWARF HORSE TAPEWORM	*Paranoplocephala mamillana*	Small intestine	Unknown	Virginia, Michigan, Montana, Idaho, Oregon, Panama (Canal Zone), Canada (British Columbia, Ontario, Saskatchewan, Quebec).
Nematodes (Roundworms)				
LARGE STOMACH-WORMS	*Habronema muscae*, *H. majus* (*H. microstoma*)	Stomach	Stable flies, *Stomoxys calcitrans*; House flies, *Musca domestica*	Generally distributed thruout North America.
	Draschia megastoma (*Habronema megastoma*)	Stomach		
SMALL HAIR WORM	*Trichostrongylus axei*	Stomach	.....	Generally...No. America.
LARGE INTESTINAL ROUNDWORM	*Parascaris equorum*	Small intestine	.....	Generally...No. America.
INTESTINAL THREADWORM	*Strongyloides westeri*	Small intestine	.....	Generally...No. America.
LARGE STRONGYLES (PALISADE WORMS)	*Strongylus equinus* *S. edentatus* *S. vulgaris*	Large intestine Large intestine Large intestine	....	Generally...No. America. Generally...No. America. Generally...No. America.

Check List of Animal Parasites of Domestic Animals in North America (United States and Possessions, and Canada)

TABLE 1. (Continued)—HORSES, MULES, AND ASSES—INTERNAL PARASITES

GROUP AND COMMON NAMES	SCIENTIFIC NAMES	LOCATION IN HOST	INTERMEDIATE HOST	GEOGRAPHICAL DISTRIBUTION
Nematodes (Roundworms)				
CECUM WORMS, SMALL STRONGYLES OR CYLICOSTOMES	*Oesophagodontus robustus*	Large intestine	.....	Generally distributed thruout No. America.
NO OTHER COMMON NAMES	*Triodontophorus minor*	Large intestine	.....	Generally...No. America.
	T. serratus	Large intestine	.....	Generally...No. America.
	T. brevicauda	Large intestine	.....	Generally...No. America.
	T. tenuicollis	Large intestine	.....	Generally...No. America.
	Craterostomum mucronatum	Large intestine	.....	Generally...No. America.
	C. acuticaudatum	Large intestine	.....	Generally...No. America.
	Cyathostomum tetracanthum	Large intestine	.....	Generally...No. America.
	C. labratum	Large intestine	.....	Generally...No. America.
	C. ornatum	Large intestine	.....	Generally...No. America.
	C. labiatum	Large intestine	.....	Generally...No. America.
	C. coronatum	Large intestine	.....	Generally...No. America.
	Cylicostephanus calicatus	Large intestine	.....	Generally...No. America.
	C. minutus	Large intestine	.....	Generally...No. America.
	C. longibursatus	Large intestine	.....	Generally...No. America.
	C. poculatus	Large intestine	.....	Generally...No. America.
	C. asymetricus	Large intestine	.....	Generally...No. America.
	C. hybridus	Large intestine	.....	Generally...No. America.
	Cylicocercus alveatus	Large intestine	.....	Generally...No. America.
	C. catinatus	Large intestine	.....	Generally...No. America.
	C. pateratus	Large intestine	.....	Generally...No. America.
	C. goldi	Large intestine	.....	Generally...No. America.
	Cylicocyclus radiatus	Large intestine	.....	Generally...No. America.
	C. auriculatus	Large intestine	.....	Generally...No. America.
	C. insigne	Large intestine	.....	Generally...No. America.
	C. elongatus	Large intestine	.....	Generally...No. America.
	C. nassatus	Large intestine	.....	Generally...No. America.
	C. leptostomus	Large intestine	.....	Generally...No. America.
	Cylicodonthophorus mettami	Large intestine	.....	Generally...No. America.
	C. bicoronatus	Large intestine	.....	Generally distributed thruout North America.
	C. euproctus	Large intestine	.....	Generally...No. America.
	C. ultrajectinus	Large intestine	.....	Generally...No. America.
	Cylicobrachytus brevicapsulatus	Large intestine	.....	Generally...No. America.
	Poteriostomum imparidentatum	Large intestine	.....	Generally...No. America.
	P. ratzii	Large intestine	.....	Generally...No. America.
	Gyalocephalus capitatus	Large intestine	.....	Generally...No. America.
PINWORMS	*Oxyuris equi*	Colon	.....	Generally...No. America.
	Probstmayria vivipara	Colon	.....	Generally...No. America.
LUNGWORM	*Dictyocaulus arnfieldi*	Bronchi	.....	Generally...No. America.
ABDOMINAL WORM	*Setaria equina*	Abdomen	Unknown	Generally...No. America.
NO COMMON NAME	*Onchocerca reticulata*	Ligamentum nuchae	*Culicoides* sp.	Generally...No. America.

Check List of Animal Parasites of Domestic Animals in North America (United States and Possessions, and Canada)

TABLE 1 (Continued).—HORSES, MULES, AND ASSES—INTERNAL PARASITES

GROUP AND COMMON NAMES	SCIENTIFIC NAMES	LOCATION IN HOST	INTERMEDIATE HOST	GEOGRAPHICAL DISTRIBUTION
Arthropods				
FLIES (IMMATURE)				
Horse botfly	*Gasterophilus intestinalis*	Stomach	.....	Generally distributed thruout North America.
Throat botfly	*G. nasalis*	Stomach and small intestine	.....	Generally distributed thruout North America, especially abundant in Rocky Mountain region. Panama (Canal Zone).
Nose botfly	*G. haemorrhoidalis*	Stomach, rectum, and anus	.....	Illinois to Eastern Oregon and Washington, Southern Canada to Central Kansas.
European horse bot	*G. inermis*	Rectum and anus	.....	Illinois.
Tropical warble fly	*Dermatobia hominis*	In and under skin	.....	Panama (Canal Zone).

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Check List of Animal Parasites of Domestic Animals in North America (United States and Possessions, and Canada)

TABLE 2.—HORSES, MULES, AND ASSES—EXTERNAL PARASITES

GROUP AND COMMON NAMES	SCIENTIFIC NAMES	LOCATION IN HOST	INTERMEDIATE HOST	GEOGRAPHICAL DISTRIBUTION
Arthropods				
TICKS				
No common name	*Ornithodoros turicata*	.....	.....	Southwestern United States and Florida.
Spinose ear tick	*Otobius megnini* (*Ornithodoros megnini*)	Ears (inside)	.....	Southwestern United States, principally.
Tropical cattle tick	*Boophilus annulatus* var. *microplus*	External	.....	Panama (Canal Zone).
Gulf Coast tick	*Amblyomma maculatum*	External	.....	States bordering on Atlantic Ocean and Gulf of Mexico, from Virginia to Mexico.
Lone Star tick	*A. americanum*	External	.....	North Atlantic, South Atlantic ,and South Central States and Ohio, Indiana, Illinois, Michigan, and Missouri.
Cayenne tick	*A. cajennense*	External	.....	Southern tip of Texas, Panama (Canal Zone).
No common name	*A. oblongoguttatum*	.....	.....	Panama (Canal Zone).
Tropical horse tick	*Otocentor nitens* (*Dermacentor nitens*)	Ears (inside)	.....	Southern tip of Texas. Puerto Rico, Panama (Canal Zone).
Moose(Winter tick)	*Dermacentor albipictus*	External	.....	South Central and Western States, principally. Canada (Nova Scotia, New Brunswick, Quebec, Manitoba, Saskatchewan, British Columbia).
American dog tick (Wood tick)	*Dermacentor variabilis*	External	.....	Eastern United States, including all the North Atlantic, North Central, South Atlantic, and South Central States; Canada (Ontario, Nova Scotia, and Labrador). California and Oregon.
Rocky Mountain spotted fever tick	*D. andersoni*	External	.....	Western States and Canada (British Columbia, Alberta, Saskatchewan).
Pacific Coast tick	*D. occidentalis*	External	.....	California and Oregon.
FLEAS				
Sticktight flea	*Echidnophaga gallinacea*	External	.....	South Carolina.
LICE				
Sucking louse	*Haematopinus asini*	External	.....	Generally distributed thruout North America.
Biting louse	*Bovicola pilosa*	External	.....	Generally...No. America.
MITES				
Sarcoptic mange mite	*Sarcoptes scabiei* var. *equi*	External	.....	Montana, Iowa, Puerto Rico.
Psoroptic mange mite	*Psoroptes equi* var. *equi*	External	.....	New Mexico, Puerto Rico.
Chorioptic mange mite	*Chorioptes bovis* var. *equi*	External	.....	New York.

Check List of Animal Parasites of Domestic Animals in North America (United States and Possessions, and Canada)

TABLE 3.—CATTLE—INTERNAL PARASITES

GROUP AND COMMON NAMES	SCIENTIFIC NAMES	LOCATION IN HOST	INTERMEDIATE HOST	GEOGRAPHICAL DISTRIBUTION
Protozoa				
AMEBAE	*Endamoeba bovis*	Large intestine	.....	Iowa.
FLAGELLATES	*Giardia bovis*	Large intestine	.....	Iowa.
	Trichomonas foetus	Genital organs	.....	Irregularly distributed thruout North America.
	T. ruminantium	Rumen	.....	Generally distributed thruout North America.
Trypanosomes	*Trypanosoma theileri*	Blood	Biting flies probably act as mechanical vectors.	Louisiana, Texas, Maryland, Panama (Canal Zone).
	T. venezuelense (*T. hippicum*)	Blood	See parasites of horses	Panama (Canal Zone).
CILIATES	*Buxtonella sulcata*	Large intestine	.....	Louisiana, Iowa.
SPOROZOA				
Coccidia	*Eimeria zurnii*	Small intestine	.....	Generally distributed thruout North America.
	E. alabamensis	Small intestine	.....	.....
	E. auburnensis	Small intestine	.....	.....
	E. bovis (*E. smithi*)	Small intestine	.....	Generally...No. America.
	E. brasiliensis	Small intestine	.....	Generally...No. America.
	E. canadensis	Small intestine	.....	Generally...No. America.
	E. cylindrica	Small intestine	.....	Generally...No. America.
	E. ellipsoidalis	Small intestine	.....	Generally...No. America.
	E. subspherica	Small intestine	.....	Generally...No. America.
	E. bukidnonensis	Small intestine	.....	New York.
	E. wyomingensis	Small intestine	.....	Wyoming.
Haemosporidia	*Babesia bigemina*	Blood (peripheral circulation)	*Boophilus annulatus* var. *microplus*	Panama (Canal Zone).
	Babesia argentina	Blood (systemic circulation)	*B. annulatus* var. *microplus*	Panama (Canal Zone).
ORGANISMS OF UNCERTAIN ZOOLOGICAL CLASSIFICATION	*Sarcocystis* sp.	Heart and voluntary muscles	Unknown	Generally distributed thruout North America.
	Eperythrozoon wenyoni	Blood	Unknown	Louisiana, Maryland, Virginia
	Bartonella sp.	Blood	Unknown	Maryland.
	Anaplasma marginale	Blood	Ticks, *Dermacentor variabilis*, *D. andersoni*, (experimental), *D. occidentalis*, *Boophilus annulatus*. Tabanids or horse flies (various species)	Delaware, Maryland, Mississippi, Arkansas, Virginia, Florida, Louisiana, Texas, Oklahoma, Kansas, Missouri, Colorado, Nevada, Idaho, Wyoming, Montana, California, Puerto Rico.

Check List of Animal Parasites of Domestic Animals in North America (United States and Possessions, and Canada)

TABLE 3 (Continued).—CATTLE—INTERNAL PARASITES

GROUP AND COMMON NAMES	SCIENTIFIC NAMES	LOCATION IN HOST	INTERMEDIATE HOST	GEOGRAPHICAL DISTRIBUTION
Trematodes (Flukes)				
COMMON LIVER FLUKE	*Fasciola hepatica*	Bile ducts	See parasites of sheep and goats	Florida, Arkansas, Louisiana, Texas, Western States, and Hawaiian Islands, Puerto Rico, Canada (British Columbia).
LARGE AMERICAN FLUKE	*Fascioloides magna*	Cysts in liver	See parasites of sheep and goats	Minnesota, Idaho, Texas, Louisiana, Arkansas, Canada (British Columbia, Alberta Ontario).
LANCET FLUKE	*Dicrocoelium dendriticum*	Liver	Unknown	New York, Northern Pennsylvania.
RUMEN FLUKE	*Paramphistomum* sp.	Rumen or paunch	See *Fasciola hepatica*	Louisiana, Texas, Florida, Arkansas, New York, Virginia, North Dakota, Montana, Oregon, Puerto Rico, Panama (Canal Zone), Canada (Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, Alberta, British Columbia).
Cestodes (Tapeworms)				
MATURE TAPEWORMS				
Common tapeworms	*Moniezia benedeni*	Small intestine	See parasites of sheep and goats	See parasites of sheep and goats.
	M. expansa	Small intestine	See parasites of sheep and goats	See parasites of sheep and goats.
IMMATURE TAPEWORMS (BLADDERWORMS)				
Thin-necked bladderworm	*Cysticercus tenuicollis*	Liver, mesentery and omentum	See parasites of sheep and goats	See parasites of sheep and goats.
Hydatid	*Echinococcus granulosus*	Liver	See parasites of sheep and goats	See parasites of swine.
Beef measles	*Cysticercus bovis*	Heart and voluntary muscles	Cattle are intermediate hosts; man is the definitive host	Generally distributed thruout North America.
Nematodes(Roundworms)				
THROAT WORM	*Syngamus laryngeus*	Larynx and trachea	.....	Puerto Rico.
GULLET WORM	*Gongylonema* spp.	Esophagus	See parasites of swine	Generally distributed thruout North America.
TWISTED STOMACH WORM	*Haemonchus contortus*	Fourth stomach or abomasum	.....	South Atlantic and South Central States, principally.
NO COMMON NAME	*H. similis*	Fourth stomach or abomasum	.....	Louisiana, Texas, Florida.
NO COMMON NAME	*Mecistocirrus digitatus*	Fourth stomach or abomasum	.....	Panama (Canal Zone).
MEDIUM STOMACH WORMS	*Ostertagia ostertagi*	Fourth stomach or abomasum	.....	Generally distributed thruout North America.
	O. lyrata	Fourth stomach or abomasum	.....	Louisiana, Virginia.
	O. bisonis	Fourth stomach or abomasum	.....	Montana.
SMALL HAIR WORMS	*Trichostrongylus axei*	Fourth stomach or absomasum	.....	Generally distributed thruout North America.
	T. longispicularis	Fourth stomach or abomasum	.....	Louisiana.

Check List of Animal Parasites of Domestic Animals in North America (United States and Possessions, and Canada)

TABLE 3 (Continued).—CATTLE—INTERNAL PARASITES

GROUP AND COMMON NAMES	SCIENTIFIC NAMES	LOCATION IN HOST	INTERMEDIATE HOST	GEOGRAPHICAL DISTRIBUTION
Nematodes (Roundworms)				
INTESTINAL WORMS				
Hookworm	*Bunostomum phlebotomum*	Small intestine	.....	See *Haemonchus contortus*.
Threadworm	*Strongyloides papillosus*	Small intestine	.....	Louisiana, Puerto Rico.
Small hair worm	*Trichostrongylus colubriformis*	Small intestine	.....	Southern United States.
Small intestinal worms	*Cooperia punctata*	Small intestine	.....	Generally distributed thruout North America.
	C. curticei	Small intestine	.....	Generally...No. America (Not common in cattle).
	C. oncophora	Small intestine	.....	Northern United States, principally.
	C. pectinata	Small intestine	.....	Southern United States, principally.
	C. bisonis	Small intestine	.....	Montana.
Thread-necked strongyles	*Nematodirus spathiger*	Small intestine	.....	Generally distributed thruout North America.
	N. helvetianus	Small intestine	.....	Northern United States, Southeastern United States (not common).
Capillarids	*Capillaria bovis*	Small intestine	.....	Southeastern United States, Puerto Rico.
	C. brevipes	Small intestine	.....	Virginia, Texas, Puerto Rico.
Large roundworm	*Neoascaris vitulorum*	Small intestine	.....	Louisiana, Puerto Rico.
Whipworms	*Trichuris ovis*	Cecum	.....	Generally distributed thruout North America.
	T. discolor	Cecum	.....	Alabama.
Nodular worm	*Oesophagostomum radiatum*	Cecum and colon	.....	South Atlantic and South Central States, principally. Puerto Rico, Panama (Canal Zone), Canada (Quebec, Ontario, British Columbia).
LUNGWORMS				
Thread lungworm	*Dictyocaulus viviparus*	Bronchi	.....	Generally distributed thruout North America.
ABDOMINAL WORM	*Setaria cervi* (*Setaria labiato-papillosa*)	Abdominal cavity	Unknown	Generally distributed thruout North America.
NO COMMON NAME	*Onchocerca gutturosa*	Ligamentum nuchae	Unknown	Puerto Rico.
NO COMMON NAME	*Onchocerca lienalis*	Splenic ligament	Unknown	Maryland.
NO COMMON NAME	*Onchocerca bovis*	Stifle joint	Unknown	Virginia.
NO COMMON NAME	*Stephanofilaria stilesi*	Skin of abdomen	Unknown	Western United States, principally, Louisiana, Virginia, Maryland.
ACANTHOCEPHALA (THORN-HEADED WORM)	*Macracanthorhynchus hirudinaceus*	Small intestine	See parasites of swine	Kansas.

Check List of Animal Parasites of Domestic Animals in North America (United States and Possessions, and Canada)

TABLE 4.—CATTLE—EXTERNAL PARASITES

GROUP AND COMMON NAMES	SCIENTIFIC NAMES	LOCATION IN HOST	INTERMEDIATE HOST	GEOGRAPHICAL DISTRIBUTION
Arthropods				
TICKS				
Cattle tick	*Boophilus annulatus*	External	.....	Panama (Canal Zone).
Tropical cattle tick	*B. annulatus* var. *microplus*	External	.....	Panama (Canal Zone).
No common name	*Amblyomma oblongoguttatum*	External	.....	Panama (Canal Zone).
Lone Star tick	*A. americanum*	External	.....	See parasites of horses.
Gulf Coast tick	*A. maculatum*	External	.....	See parasites of horses.
Black-legged tick (Shoulder tick)	*Ixodes scapularis*	External	.....	See parasites of horses.
American dog tick (Wood tick)	*Dermacentor variabilis*	External	.....	See parasites of horses.
Rocky Mountain spotted fever tick	*D. andersoni*	External	.....	See parasites of horses.
Pacific Coast tick	*D. occidentalis*	External	.....	See parasites of horses.
Moose or winter tick	*D. albipictus*	External	.....	See parasites of horses.
Spinose ear tick	*Otobius megnini* (*Ornithodoros megnini*)	Ears (inside)	.....	See parasites of horses.
Tropical horse tick	*Otocentor nitens* (*Dermacentor nitens*)	Ears (inside)	.....	See parasites of horses.
No common name	*Ornithodoros turicata*	.....	.....	Arizona, California, Florida, New Mexico.
LICE				
Sucking lice				
Short-nosed cattle louse	*Haematopinus eurysternus*	External	.....	Generally distributed thruout North America.
Long-nosed or blue cattle louse	*Linognathus vituli*	External	.....	Generally distributed thruout United States.
Hairy cattle louse	*Solenopotes capillatus*	External	.....	Generally distributed thruout United States.
Tail louse	*Haematopinus tuberculatus*	Switch of tail	.....	Puerto Rico.
Biting lice				
Common red louse	*Bovicola bovis*	External	.....	Generally distributed thruout North America.
MITES				
Common scab mite	*Psoroptes equi* var. *bovis*	External	.....	Irregularly distributed thruout North America.
Sarcoptic scab mite	*Sarcoptes scabiei*	In burrows in skin	.....	Vermont, Massachusetts, New York, Virginia, North Carolina, Ohio, Texas, Colorado, California.
Follicle mite	*Demodex folliculorum*	In burrows in skin	.....	Kansas, Maryland.
Arthropods				
FLIES (IMMATURE)				
Common cattle grub	*Hypoderma lineatum*	Under skin of back	.....	Generally distributed thruout North America.
Northern cattle grub	*Hypoderma bovis*	Under skin of back	.....	North Atlantic and North Central States, Montana, Wyoming, Oregon, Washington, Canada.
Tropical warble fly	*Dermatobia hominis*	Under skin	.....	Panama (Canal Zone).
Screw-worm	*Cochliomyia americana*	In wounds	.....	Southern United States.
Secondary screw-worm	*C. macellaria*	In wounds	.....	Southern United States.
Black blowfly	*Phormia regina*	In wounds	.....	Texas, California, Canada (British Columbia).

Check List of Animal Parasites of Domestic Animals in North America (United States and Possessions, and Canada)

TABLE 5.—SWINE—INTERNAL PARASITES

GROUP AND COMMON NAMES	SCIENTIFIC NAMES	LOCATION IN HOST	INTERMEDIATE HOST	GEOGRAPHICAL DISTRIBUTION
Protozoa				
AMEBAE	*Endamoeba coli*	Large intestine	.....	Generally distributed thruout No. America.
	E. polecki	Large intestine	.....	Generally....No. America.
	Iodamoeba sp.	Large intestine	.....	Generally....No. America.
	Endolimax sp.	Large intestine	.....	Generally....No. America
FLAGELLATES	*Giardia* sp.	Large intestine	.....	Generally....No. America.
	Chilomastix sp.	Large intestine	.....	Genezally....No. America.
	Trichomonas suis	Large intestine	.....	Generally....No. America.
CILIATES	*Balantidium coli*	Large intestine	.....	Generally....No. America.
SPOROZOA				
Coccidia	*Eimeria debliecki*	Large intestine	.....	Generally....No. America.
	E. perminuta	Large intestine	.....	Generally....No. America.
	E. scabra	Large intestine	.....	Generally....No. America.
	E. scrofa	Large intestine	.....	Generally....No. America.
	E. spinosa	Large intestine	.....	Generally....No. America.
	Isospora suis	Large intestine	.....	Iowa.
Trematodes (Flukes)				
COMMON LIVER FLUKE	*Fasciola hepatica*	Bile ducts	See parasites of sheep and goats.	See parasites of sheep and goats.
LUNG FLUKE	*Paragonimus westermanni*	Lungs	See parasites of dogs and cats.	See parasites of dogs and cats.
Cestodes (Tapeworms)				
IMMATURE TAPEWORMS (BLADDERWORMS)				
Thin-necked bladderworm	*Cysticercus tenuicollis*	Liver, mesentery and omentum	Swine are the intermediate hosts.	Generally distributed thruout No. America.
Pork bladderworm	*Cysticercus cellulosae*	Muscles	Swine are the intermediate hosts.	Montana, Texas, Louisiana, Puerto Rico, Canada (Alberta).
Hydatid	*Echinococcus granulosus*	Liver and lungs	Swine are the intermediate hosts.	Virginia, Georgia, Alabama, Mississippi, Texas, Kansas, Louisiana, Canada (Quebec, British Columbia).
Nematodes (Roundworms)				
GULLET WORM	*Gongylonema pulchrum*	Esophagus	Various coprophagous or dung beetles; cockroaches.	Generally distributed thruout No. America.
RED STOMACH WORM	*Hyostrongylus rubidus*	Stomach	.....	Generally....No. America.
THICK STOMACH WORMS	*Ascarops strongylina*	Stomach	Various coprophagous or dung bettelen.	Generally distributed thruout United States.
	Physocephalus sexalatus	Stomach	Various coprophagous or dung beetles.	Generally distributed thruout United States.
INTESTINAL THREAD WORM	*Strongyloides ransomi*	Small intestine	.....	Generally distributed thruout No. America.
LARGE INTESTINAL ROUNDWORM	*Ascaris lumbricoides*	Small intestine	.....	Generally....No. America.
SWINE HOOKWORMS	*Globocephalus urosubulatus*	Small intestine	.....	South Atlantic and South Central States, Puerto Rico.
	Necator suillus	Small intestine	.....	Panama (Canal Zone).
WHIPWORM	*Trichuris suis*	Cecum	.....	Generally distributed thruout No. America.

Check List of Animal Parasites of Domestic Animals in North America (United States and Possessions, and Canada)

TABLE 5 (Continued).—SWINE—INTERNAL PARASITES

GROUP AND COMMON NAMES	SCIENTIFIC NAMES	LOCATION IN HOST	INTERMEDIATE HOST	GEOGRAPHICAL DISTRIBUTION
Nematodes (Roundworms)				
NODULAR WORMS	*Oesophagostomum dentatum*	Cecum and colon	.....	Generally distributed thruout North America.
	O. longicaudum	Cecum and colon	.....	South Atlantic States, Puerto Rico.
	O. brevicaudum	Cecum and colon	.....	South Atlantic States.
	O. georgianum	Cecum and colon	.....	South Atlantic States.
KIDNEY WORM	*Stephanurus dentatus*	Perirenal fat, kidneys and ureters, occasionally in lungs	.....	South Atlantic, North and South Central States, principally, Puerto Rico, Panama (Canal Zone).
LUNGWORMS	*Metastrongylus elongatus*	Bronchi	Earthworms of the genus, Helodrilus	Generally distributed thruout North America.
	M. salmi	Bronchi	Earthworms of the genus, Helodrilus	Generally...North America.
	Choerostrongylus pudendotectus	Bronchi	Earthworms of the genus, Helodrilus	Generally...North America.
TRICHINA	*Trichinella spiralis*	Adults in small intestine, larvae in muscles	.....	Generally distributed thruout United States and possessions, most common in garbage fed hogs.
Acanthocephala (Thorn-headed worm)	*Macracanthorhynchus hirudinaceus*	Small intestine	White grubs or May beetle larvae	Generally distributed thruout United States, Canada (Southwestern Ontario).
Arthropods				
FLIES (IMMATURE)				
Botflies				
Horse botfly	*Gasterophilus intestinalis*	Stomach	.....	Indiana (Indianapolis), Illinois (Chicago), South Dakota (Sioux Falls) Nebraska (Omaha) Colorado (Pueblo).
Nose botfly	*Gasterophilus haemorrhoidalis*	Stomach	.....	Kansas (Kansas City).
Rodent botfly	*Cuterebra* sp.	Throat, trachea	.....	Georgia, Tennessee, Virginia.
Screw-worm	*Cochliomyia americana*	In wounds	.....	See parasites of cattle.
Secondary screw-worm	*C. macellaria*	In wounds	.....	See parasites of cattle.

Check List of Animal Parasites of Domestic Animals in North America (United States and Possessions, and Canada)

TABLE 6.—SWINE—EXTERNAL PARASITES

GROUP AND COMMON NAMES	SCIENTIFIC NAMES	LOCATION IN HOST	INTERMEDIATE HOST	GEOGRAPHICAL DISTRIBUTION
Arthropods				
TICKS				
No common name	*Ornithodoros turicata*	External	.....	Florida.
Spinose ear tick	*Otobius megnini*	Ears (inside)	.....	See parasites of horses.
Lone Star tick	*Amblyomma americanum*	External	.....	See parasites of horses.
Gulf Coast tick	*A. maculatum*	External	.....	See parasites of horses.
No common name	*A. oblongoguttatum*	External	.....	Panama (Canal Zone).
Rocky Mountain spotted fever tick	*Dermacentor andersoni*	External	.....	See parasites of horses.
American dog tick (Wood tick)	*D. variabilis*	External	.....	See parasites of horses.
Tropical horse tick	*Otocentor nitens*	Ears (inside)	.....	Puerto Rico.
Black-legged tick (Shoulder tick)	*Ixodes scapularis*	External	.....	Florida.
FLEAS				
Chigoe	*Tunga penetrans*	Underneath skin	.....	Puerto Rico.
Human flea	*Pulex irritans*	External	.....	Oregon, Illinois, Missouri, Virginia.
Sticktight flea	*Echidnophaga gallinacea*	External	.....	(Trembly and Bishopp, 1940, locality not given).
LICE				
Common hog louse	*Haematopinus adventicius* var. *chinensis* (*H. suis*)	External	.....	Generally distributed thruout North America.
MITES				
Sarcoptic scab mite	*Sarcoptes scabiei*	In skin	.....	Generally distributed thruout North America.
Follicle mite	*Demodex folliculorum*	In skin	.....	Generally distributed thruout North America.

Check List of Animal Parasites of Domestic Animals in North America (United States and Possessions, and Canada)

TABLE 7.—SHEEP AND GOATS—INTERNAL PARASITES

GROUP AND COMMON NAMES	SCIENTIFIC NAMES	LOCATION IN HOST	INTERMEDIATE HOST	GEOGRAPHICAL DISTRIBUTION
Protozoa				
FLAGELLATES	*Embadomonas ovis*	Intestine	.....	Maryland.
CILIATES	*Balantidium* sp.	Cecum and colon	.....	Maryland.
SPOROZOA				
Coccidia	*Eimeria arloingi*	Small intestine	.....	Generally distribute dthruout North America.
	E. faurei	Small intestine	.....	Generally . . . No. America.
	E. intricata	Small intestine	.....	Generally . . . No. America.
	E. granulosa	Small intestine	.....	Generally, . . . No. America
	E. pallida	Small intestine	.....	Generally . . . No. America.
	E. parva	Small intestine	.....	Generally . . . No. America.
	E. nina-kohl-yakimovi	Small intestine	.....	Generally . . . No. America.
	E. ah-sa-ta	Small intestine	.....	Wyoming.
ORGANISMS OF UNCERTAIN ZOOLOGICAL CLASSIFICATION	*Sarcocystis tenella*	Muscles	.....	Generally distributed thruout North America.
	Globidium sp.	Small intestine	.....	Montana.
	Eperythrozoon sp.	Blood	.....	Louisiana.
	Toxoplasma sp.	Brain (medulla, cerebellum, mid-brain)	.....	New York (Ithaca).
Trematodes (Flukes)				
COMMON LIVER FLUKE	*Fasciola hepatica*	Bile ducts	Aquatic snails, *Lymnea (Galba) bulimoides, L. (Galba) bulimoides techella*	See parasites of cattle.
LARGE AMERICAN FLUKE	*Fascioloides magna*	Liver (parenchyma)	Aquatic snails, *Lymnea (Galba) bulimoides, L. (Galba) bulimoides techella. Fossaria parva, Stagnicola palustris nuttaliana*	See parasites of cattle.
RUMEN FLUKE	*Cotylophoron* sp.	Rumen	Unknown	New York (Ithaca).
LANCET FLUKE	*Dicrocoelium dendriticum*	Liver	Unknown	Canada (Nova Scotia, Cape Breton).
Cestodes (Tapeworms)				
MATURE TAPEWORMS Common tapeworms	*Moniezia expansa*	Small intestine	Free living oribatid mites, *Galumna nigra, Galumna emarginata, Galumna* sp.	Generally distributed thruout North America.
	M. benedeni	Small intestine	Free living oribatid mites, *Galumna nigra, Galumna emarginata, Galumna* sp.	Generally . . . No. America.
Fringed tapeworm	*Thysanosoma actinioides*	Bile ducts and small intestine	Unknown	Western United States and Canada.

Check List of Animal Parasites of Domestic Animals in North America (United States and Possessions, and Canada)

TABLE 7 (Continued).—SHEEP AND GOATS—INTERNAL PARASITES

GROUP AND COMMON NAMES	SCIENTIFIC NAMES	LOCATION IN HOST	INTERMEDIATE HOST	GEOGRAPHICAL DISTRIBUTION
Cestodes (Tapeworms)				
IMMATURE TAPEWORMS (BLADDERWORMS)				
Thin necked bladderworm	*Cysticercus tenuicollis*	Liver, mesentery, and omentum	Sheep and goats are intermediate hosts; dogs are the deifnitive hosts	Generally distributed thruout North America.
Gid bladderworm	*Coenurus cerebralis* or *Multiceps multiceps*	Brain and spinal cord	Sheep and goats are intermediate hosts; dogs are the definitive hosts	Montana.
Hydatid	*Echinococcus granulosus*	Liver and lungs	Sheep and goats are intermediate hosts; dogs are the definitive hosts	See parasites of swine.
Sheep measles	*Cysticercus ovis*	Muscles	Sheep and goats are intermediate hosts; dogs are the definitive hosts	Western United States principally, Canada (British Columbia, Manitoba).
Nematodes(Roundworms)				
THROATWORM	*Syngamus laryngeus*	Trachea	.....	Puerto Rico.
GULLET WORMS	*Gongylonema pulchrum*	Esophagus	Various coprophagous or dung beetles	Generally distributed thruout North America.
	G. verrucosum	Rumen	Various coprophagous or dung beetles	Generally distributed thruout North America.
STOMACH WORMS Twisted stomach worm	*Haemonchus contortus*	Abomasum or fourth stomach	.....	Generally distributed thruout North America.
Medium stomach worms	*Ostertagia circumcincta*	Abomasum or fourth stomach	.....	Generally...No. America.
	O. trifurcata	Abomasum or fourth stomach	.....	Generally...No. America.
	O. marshalli	Abomasum fourth stomach	.....	Western United States.
	O. occidentalis	Abomasum or fourth stomach	.....	Western United States.
	Pseudostertagia bullosa	Abomasum or fourth stomach	.....	South Dakota, Colorado.
Small hair worm	*Trichostrongylus axei*	Abomasum or fourth stomach	.....	Generally distributed thruout North America.

Check List of Animal Parasites of Domestic Animals in North America (United States and Possessions, and Canada)

TABLE 7 (Continued).—SHEEP AND GOATS—INTERNAL PARASITES

GROUP AND COMMON NAMES	SCIENTIFIC NAMES	LOCATION IN HOST	INTERMEDIATE HOST	GEOGRAPHICAL DISTRIBUTION
Nematodes (Roundworms)				
INTESTINAL WORMS				
Hookworm	*Bunostomum trigonocephalum*	Small intestine	.....	Generally...No. America.
Small hairworms	*Trichostrongylus colubriformis*	Small intestine	.....	Generally...No. America.
	T. vitrinus	Small intestine	.....	Generally...No. America.
	T. capricola	Small intestine	.....	Generally...No. America.
Small intestinal worms	*Cooperia curticei*	Small intestine, rarely abomasum	.....	Generally distributed thruout North America.
	C. punctata	Small intestine, rarely abomasum	.....	Generally...No. America.
	C. oncophora	Small intestine, rarely abomasum	.....	Northern United States, principally, Canada (Ontario, Quebec).
	C. pectinata	Small intestine, rarely abomasum	.....	Southern United States, principally.
Thread worm	*Strongyloides papillosus*	Small intestine,	.....	Generally distributed thruout North America.
Thread necked strongyles	*Nematodirus spathiger*	Small intestine,	.....	Generally...No. America.
	N. filicollis	Small intestine,	.....	Generally...No. America.
	N. abnormalis	Small intestine,	.....	North and South Dakota.
Capillarids	*Capillaria brevipes*	Small intestine,	.....	Generally distributed thruout North America.
	C. bovis	Small intestine,	.....	Generally...No. America.
Whipworm	*Trichuris ovis*	Cecum	.....	Generally...No. America.
Nodular worms	*Oesophagostomum columbianum*	Cecum and colon	.....	North Atlantic, North Central, South Atlantic and South Central States and Canada (Manitoba to Atlantic Coast).
	O. venulosum	Cecum and colon	.....	North Atlantic, North Central, South Atlantic and South Central States and Canada (British Columbia).
Large mouthed bowel worm	*Chabertia ovina*	Colon	.....	North Atlantic, North Central, South Atlantic and South Central States and Canada (Dominion wide).
Pinworm	*Skrjabinema ovis*	Cecum and colon	.....	Nebraska, Maryland, Massachusetts.
LUNGWORMS				
Thread lungworm	*Dictyocaulus filaria*	Bronchi	.....	Generally distributed thruout North America.
Hair lungworm	*Muellerius capillaris*	Bronchioles and lung parenchyma	Various species of land snails	Generally...No. America.
EYEWORM	*Thelazia californiensis*	Tear ducts	Unknown	California.
NO COMMON NAME	*Elaeophora schneideri*	Carotid and external iliac arteries	Unknown	New Mexico, Arizona, Colorado.

Check List of Animal Parasites of Domestic Animals in North America (United States and Possessions, and Canada)

TABLE 8.—SHEEP AND GOATS—EXTERNAL PARASITES

GROUP AND COMMON NAMES	SCIENTIFIC NAMES	LOCATION IN HOST	INTERMEDIATE HOST	GEOGRAPHICAL DISTRIBUTION
Arthropods				
MITES				
Common scab mite	*Psoroptes equi* var. *ovis*	External	.....	Irregularly distributed thruout North America.
Foot scab mite	*Chorioptes ovis* var. *ovis*	Skin of feet	.....	Texas, Ohio.
Demodectic scab mite (Follicle mite)	*Demodex folliculorum*	External	.....	Minnesota, Nevada.
FLIES (IMMATURE)				
Sheep botfly	*Oestrus ovis*	Nasal cavities and sinuses of head	.....	Generally distributed thruout North America.
Blowflies	*Lucilia sericata*	On skin or in wounds	.....	Generally...No. America.
	Phormia regina	On skin or in wounds	.....	Texas, Canada (British Columbia).
Screw-worm	*Cochliomyia americana*	In wounds	.....	Texas and adjacent states, principally.
Secondary screw-worm	*C. macellaria*	In wounds	.....	Texas and adjacent states, principally.
Tropical warble fly	*Dermatobia hominis*	In and under skin	.....	Panama (Canal Zone).
TICKS				
Rocky Mountain spotted fever tick	*Dermacentor andersoni*	External	.....	See parasites of horses.
American dog tick (Wood tick)	*D. variabilis*	External	.....	See parasites of horses.
Pacific Coast tick	*D. occidentalis*	External	.....	See parasites of horses.
Gulf Coast tick	*Amblyomma maculatum*	External	.....	See parasites of horses.
Lone Star tick	*A. americanum*	External	.....	See parasites of horses.
Black-legged tick	*Ixodes scapularis*	External	.....	See parasites of horses.
Spinose ear tick	*Otobius megnini*	External	.....	See parasites of horses.
LOUSE FLIES				
Sheep tick (Sheep ked)	*Melophagus ovinus*	External	.....	Generally distributed thruout North America.
LICE				
Sucking lice	*Linognathus stenopsis*	External	.....	In United States reported chiefly from Texas.
	L. africanus	External	.....	In United States reported chiefly from Texas.
	L. ovillus	External	.....	In United States reported chiefly from Texas.
	L. pedalis	External	.....	In United States reported chiefly from Texas.
Biting lice	*Bovicola limbata*	External	.....	In United States reported chiefly from Texas. Canada (Quebec).
	B. caprae	External	.....	In United States reported chiefly from Texas.
	B. ovis	External	.....	In United states reported chiefly from Texas. Canada (Common in Eastern Canada).
	B. peregrina	External	.....	In United States reported chiefly from Texas.
	B. hermsi	External	.....	In United States reported chiefly from Texas.

Check List of Animal Parasites of Domestic Animals in North America (United States and Possessions, and Canada)

TABLE 9.—DOGS AND CATS—INTERNAL PARASITES

GROUP AND COMMON NAMES	SCIENTIFIC NAMES	LOCATION IN HOST	INTERMEDIATE HOST	GEOGRAPHICAL DISTRIBUTION
Protozoa				
AMEBAE	*Endamoeba histolytica*	Large intestine	.....	Maryland.
	Endamoeba sp.	Large intestine	.....	Maryland.
FLAGELLATES	*Giardia canis*	Large intestine	.....	Maryland .
	Trichomonas canistomae	Mouth	.....	Maryland.
	T. felistomae	Mouth	.....	Maryland.
	Trichomonas sp.	Intestine	.....	Kansas.
SPOROZOA Coccidia	*Isospora rivolta*	Small intestine	.....	Widely distributed thruout North America.
	I. bigemina	Small intestine	.....	Widely distributed thruout North America.
	I. felis	Small intestine	.....	Widely distributed thruout North America.
	Eimeria canis	Small intestine	.....	Nebraska.
Haemosporidia	*Babesia canis*	Blood	*Rhipicephalus sanguineus*	Florida, Puerto Rico, Panama (Canal Zone).
ORGANISMS OF UNCERTAIN ZOOLOGICAL CLASSIFICATION	*Toxoplasma* sp.	Intestine, mesenteric lymph glands	.....	New York.
Trematodes (Flukes)				
NO COMMON NAME	*Metorchis conjunctus*	Gall bladder	Snail-*Amnicola limosa porata*; Common sucker-*Catostomus commersonii*	New York, Canada.
NO COMMON NAME	*Parametorchis complexus*	Bile ducts	Unknown	New York, Maryland, District of Columbia.
NO COMMON NAME	*Amphimerus pseudofelineus*	Bile ducts	Unknown	Nebraska, Iowa, Maryland, Virginia.
NO COMMON NAME	*Apophallus donicus*	Small intestine	Snails and fishes	District of Columbia.
NO COMMON NAME	*Cryptocotyle lingua*	Small intestine	Snails-*Littorina littorea*, *Paludestrinas stagnicola*	Michigan.
NO COMMON NAME	*Phagicola longa*	Small intestine	Snails and fishes-*Mugil cephalus M. capito*, *Lichia amia*, *Barbus canis*	Alaska.
NO COMMON NAME	*Alaria americana*	Small intestine	Unknown	Michigan, New York, Minnesota, Louisiana.
NO COMMON NAME	*A. michiganensis*	Small intestine	Unknown	Michigan.
NO COMMON NAME	*A. arisaemoides*	Small intestine	Unknown	Oregon.
NO COMMON NAME	*A. canis*	Small intestine	Unknown	Canada (Ontario).
NO COMMON NAME	*Prohemistomum appendiculatum*	Small intestine	Snails and fishes	District of Columbia.
NO COMMON NAME	*Platynosomum fastosum*	Liver and small intestine	Unknown	Puerto Rico.
NO COMMON NAME	*Echinochasmus schwartzi*	Small intestine	Unknown	District of Columbia.
LUNG FLUKE	*Paragonimus westermanni*	Tissue of lung	Snails-*Pomiatopsis lapidaria* and crayfishes of the genus *Cambarus*	Ohio, Indiana, California, Louisiana, Michigan, Wisconsin, West Virginia, Minnesota, New York, Mississippi, Iowa, Missouri.
SALMON POISONING FLUKE	*Troglotrema salmincola*	Small intestine	Snail-*Goniobasis plicifera* var. *silicula*; Fishes-*Salmo clarkii*, *S. iridiens*, *S. gairdneriі*, *Salvelinus frontalis*	Oregon, Washington, California.

Check List of Animal Parasites of Domestic Animals in North America (United States and Possessions, and Canada)

TABLE 9 (Continued).—DOGS AND CATS—INTERNAL PARASITES

GROUP AND COMMON NAMES	SCIENTIFIC NAMES	LOCATION IN HOST	INTERMEDIATE HOST	GEOGRAPHICAL DISTRIBUTION
Cestodes (Tapeworms)				
ARMED TAPEWORMS Double pored tapeworms				
No common name	*Dipylidium caninum*	Small intestine	Dog and cat fleas, *Ctenocephalides canis, C. felis,* and dog and cat lice, *Trichodectes canis* and *Felicola subrostrata*	Generally distributed thruout North America.
No common name	*D. sexcoronatum*	Small intestine	Dog and cat fleas, *Ctenocephalides canis, C. felis,* and dog and cat lice, *Trichodectes canis* and *Felicola subrostrata*	Generally...No. America.
Single pored tapeworms No common name	*Taenia taeniaeformis*	Small intestine	Mice, rats, and other rodents	Generally...No. America.
No common name	*Taenia pisiformis*	Small intestine	Rabbits and hares	Generally...No. America.
No common name	*T. hydatigena*	Small intestine	Sheep, goats, cattle and swine	Generally...No. America.
No common name	*T. ovis*	Small intestine	Sheep and goats	Generally...No. America.
No common name	*T. balaniceps*	Small intestine	Unknown	Nevada, Colorado, New Mexico.
Gid tapeworm	*Multiceps multiceps*	Small intestine	Sheep and cattle	Montana, Ohio, New York, Colorado.
No common name	*Multiceps serialis*	Small intestine	Rabbits, hares and squirrels	Louisiana, Texas.
Hydatid tapeworm	*Echinococcus granulosus*	Small intestine	Domestic and wild ruminants, swine and man	See parasites of swine.
UNARMED TAPEWORMS Broad fish tapeworm	*Diphyllobothrium latum*	Small intestine	Copepods and fishes, Northern pike, *Esox lucius,* wall-eyed pike, *Stizostedion vitreum*	States bordering on Great Lakes, Florida.
No common name	*D. cordatum*	Small intestine	Unknown	Canada (Ontario).
No common name	*D. mansoni*	Small intestine	Copepods and frogs, *Leptidactylus albilabris,* snakes	Puerto Rico, Panama (Canal Zone).
No common name	*D. mansonoides*	Small intestine	Cyclops, *Cyclops leuckarti, C. viredis C. bicuspidatus;* Mice, *Peromyscus gossipinus;* Snakes, *Natrix sipedon*	Louisiana, New York.
No common name	*Mesocestoides latus*	Small intestine	Unknown	Minnesota.
No common name	*M. lineatus*	Small intestine	Unknown	Nebraska.
Nematodes (Roundworms)				
NO COMMON NAME	*Physaloptera felidis*	Stomach	Unknown	Kansas.
NO COMMON NAME	*P. praeputialis*	Stomach	Unknown	Ohio, Panama (Canal Zone), Puerto Rico.
NO COMMON NAME	*P. pacilae*	Stomach	Unknown	Panama (Canal Zone).
LARGE ROUNDWORMS	*Toxocara canis*	Small intestine	.....	Generally distributed thruout North America.
	T. mystax	Small intestine	.....	Generally...No. America.
	Toxascaris leonina	Small intestine	.....	Generally...No. America.

Check List of Animal Parasites of Domestic Animals in North America (United States and Possessions, and Canada)

TABLE 9 (Continued).—DOGS AND CATS—INTERNAL PARASITES

GROUP AND COMMON NAMES	SCIENTIFIC NAMES	LOCATION IN HOST	INTERMEDIATE HOST	GEOGRAPHICAL DISTRIBUTION
Nematodes (Roundworms)				
HOOKWORMS	*Ancylostoma caninum*	Small intestine	.....	Generally . . . No. America.
	A. brasiliense	Small intestine	.....	Southern United States, Puerto Rico, Panama (Canal Zone).
	Uncinaria stenocephala	Small intestine	.....	Alaska, Maryland.
NO COMMON NAME	*Strongyloides stercoralis* var. *canis*	Small intestine	.....	Connecticut, North Carolina, New York, Maryland, Virginia, Louisiana.
NO COMMON NAME	*S. tumefaciens*	Large intestine	.....	Florida, Louisiana, Texas.
NO COMMON NAME	*Capillaria lineare*	Small intestine	.....	Pennsylvania.
WHIPWORMS	*Trichuris vulpis*	Cecum	.....	Generally distributed thruout North America.
	T. felis (*T. campanula*)	Cecum	.....	Ohio.
NO COMMON NAME	*Capillaria hepatica*	Liver	.....	District of Columbia.
BLADDER WORM	*C. plica*	Urinary bladder	.....	New York, Maryland, Virginia, Louisiana, Puerto Rico.
LUNGWORMS	*Capillaria aerophila*	Lungs	.....	Massachusetts, New York Canada.
	Aelurostrongylus abstrusus	Lungs	Mice	Maryland, Puerto Rico.
	Filarioides osleri	Trachea, bronchi	.....	Southern United States, Hawaii, Panama (Canal Zone).
ESOPHAGEAL WORM	*Spirocerca lupi*	Esophagus, stomach, aorta	.....	Texas, Louisiana, Alabama, North Dakota.
HEARTWORM	*Dirofilaria immitis*	Heart and pulmonary artery	Mosquitoes of the genera *Aedes*, *Culex* and *Anopheles*	Southern United States, principally.
KIDNEY WORM	*Dioctophyma renale*	Kidneys, abdominal cavity	Unknown	South Carolina, North Carolina, Virginia, Maryland, District of Columbia, Ohio.
EYEWORM	*Thelazia californiensis*	Tear ducts, under eyelids	Unknown	California.
GUINEA WORM	*Dracunculus medinensis*	Under skin	Unknown	Iowa.
TRICHINA	*Trichinella spiralis* (Larvae)	Diaphragm	.....	Minnesota.
NO COMMON NAME	*Rhabditis strongyloides*	Skin	.....	New York.
Acanthocephala (Thorn-headed worms)				
NO COMMON NAME	*Oncicola canis*	Small intestine	Unknown	Texas, Pennsylvania, Ohio.
NO COMMON NAME	*Corynosoma* sp.	Small intestine	Unknown	Puerto Rico.
Arthropods				
FLIES (IMMATURE)				
Bot Flies				
Rodent bot	*Cuterebra* spp.	Under skin	.....	Generally distributed thruout United States.
Screw-worm	*Cochliomyia americana*	In wounds	.....	Florida, Georgia, South Carolina, Louisiana.
Secondary screw-worm	*C. macellaria*	In wounds	.....	Georgia, Florida.
No common name	*Wohlfahrtia vigil*	.....	.....	Montana, Canada (Ontario).
Tropical warble fly	*Dermatobia hominis*	Under skin	.....	Panama (Canal Zone).
ARACHNIDS				
Tongue worm	*Linguatula serrata*	Nasal cavities	Cattle, sheep, goat and rabbits.	Maryland, Tennessee, North Carolina, Alabama, Georgia, Texas, New York.

Check List of Animal Parasites of Domestic Animals in North America (United States and Possessions, and Canada)

TABLE 10.—DOGS AND CATS—EXTERNAL PARASITES

GROUP AND COMMON NAMES	SCIENTIFIC NAMES	LOCATION IN HOST	INTERMEDIATE HOST	GEOGRAPHICAL DISTRIBUTION
Arthropods				
TICKS				
Brown dog tick	*Rhipicephalus sanguineus*	External	.....	Occurs naturally in Southern States principally.
Lone Star tick	*Amblyomma americanum*	External	.....	Southeastern United States, Texas, Oklahoma, Arkansas, Missouri, Iowa, Louisiana.
Gulf Coast tick	*A. maculatum*	External	.....	Gulf Coast States principally, Oklahoma.
No common name	*A. inornatum*	External	.....	Texas.
No common name	*A. oblongoguttatum*	External	.....	Panama (Canal Zone).
No common name	*A. auricularium*	External	.....	Panama (Canal Zone).
No common name	*A. ovale*	External	.....	Panama (Canal Zone), Iowa.
Black-legged (Shoulder tick)	*Ixodes scapularis*	External	.....	Maryland south to Florida, Iowa, Missouri, Texas and Louisiana.
California black-legged tick	*I. pacificus*	External	.....	California.
No common name	*I. texanus*	External	.....	Iowa.
No common name	*I. bicornis*	External	.....	Panama (Canal Zone).
No common name	*I. cookei*	External	.....	Oregon, Washington, California, Canada (Provinces east of Ontario).
No common name	*I. sculptus*	External	.....	Oregon.
No common name	*I. angustus*	External	.....	Washington.
Rotund tick	*I. kingi*	External	.....	Montana, Idaho, Wyoming, Utah.
American dog tick (Wood tick)	*Dermacentor variabilis*	External	.....	Eastern United States, principally, Canada (Eastern Canada).
Rocky Mountain spotted fever tick	*D. andersoni*	External	.....	Canada (Saskatchewan Southern Alterta, British Columbia), thence south to Northern New Mexico, foothills of Rocky Mountains in Colorado to base of Cascade Range in Oregon and California in United States.
Pacific Coast tick	*D. occidentalis*	External	.....	California and Oregon.
Spinose ear tick	*Otobius megnini* (*Ornithodoros megnini*)	In ears	.....	Texas, Oklahoma, Kansas, Nebraska, South Dakota, Wyoming, Montana, Idaho, Washington, Oregon, California, Nevada, Utah, Colorado, New Mexico and Arizona. British Columbia.
No common name	*Otobius lagophilus*	External	.....	Canada (Alberta).
No common name	*Ornithodoros talaje* (larvae)	External	.....	Panama.
Rabbit tick	*Haemaphysalis leporis-palustris*	External	.....	Iowa.

Check List of Animal Parasites of Domestic Animals in North America (United States and Possessions, and Canada)

TABLE 10 (Continued).—DOGS AND CATS—EXTERNAL PARASITES

GROUP AND COMMON NAMES	SCIENTIFIC NAMES	LOCATION IN HOST	INTERMEDIATE HOST	GEOGRAPHICAL DISTRIBUTION
Arthropods				
FLEAS				
Dog flea	*Ctenocephalides canis*	External	.....	Widely distributed thruout North America.
Cat flea	*C. felis*	External	.....	Widely...No. America.
Human flea	*Pulex irritans*	External	.....	New Jersey, Maryland, North Carolina, Georgia, Montana, California, Puerto Rico, Panama (Canal Zone).
Sticktight flea	*Echidnophaga gallinacea*	External	.....	Alabama, Arkansas, North Carolina, Virginia, Texas, Hawaii.
No common name	*Cediopsylla simplex*	External	.....	Iowa, Maryland, Massachusetts.
No common name	*C. inaequalis*	External	.....	Montana, Massachusetts, North Carolina.
No common name	*Hoplopsylla affinis*	External	.....	Montana.
No common name	*Rhopalopsyllus sigmodoni*	External	.....	Texas.
No common name	*Odontopsyllus multispinosus*	External	.....	Iowa.
No common name	*Opisocrostis bruneri*	External	.....	Iowa.
No common name	*Orchopeas wickhami*	External	.....	Not given.
No common name	*O. leucopus*	External	.....	Iowa.
No common name	*Tamiophila grandis*	External	.....	Vermont.
Chigoe	*Tunga penetrans*	External	.....	Panama (Canal Zone).
LICE				
Sucking lice				
No common name	*Linognathus setosus*	External	.....	Widely distributed thruout North America.
Kangaroo louse	*Heterodoxus longitarsus*	External	.....	Oklahoma, Mississippi, Puerto Rico.
Biting lice				
No common name	*Trichodectes canis*	External	.....	Widely distributed thruout North America.
No common name	*T. floridanus*	External	.....	Oklahoma, Florida.
No common name	*Felicola subrostrata*	External	.....	Widely distributed thruout North America.
MITES				
Sarcoptic scab mite	*Sarcoptes scabiei*	In burrows in skin	.....	Widely...No. America.
No common name	*Notoedres cati*	In burrows in skin	.....	Widely...No. America.
Ear Mite	*Otodectes cynotis*	In ears	.....	Widely...No. America.
Red mange mite (Follicle mite)	*Demodex folliculorum*	In skin	.....	Widely...No. America.
Cheese mite	*Tyroglyphus* sp.	External	.....	Virginia.
Chiggers	*Eutrombicula alfreddugesi* (*Trombicula irritans*)	In skin	.....	Widely distributed thruout North America.
No common name	*Pneumonyssus caninum*		.....	Michigan, New York, Pennsylvania.

Check List of Animal Parasites of Domestic Animals in North America (United States and Possessions, and Canada)

TABLE 11.—BIRDS (CHICKENS, TURKEYS, GUINEA FOWL, DUCKS, GEESE, AND PIGEONS)—INTERNAL PARASITES

GROUP AND COMMON NAMES	SCIENTIFIC NAMES	LOCATION IN HOST	INTERMEDIATE HOST	GEOGRAPHICAL DISTRIBUTION
Protozoa				
AMEBAE				
No common name	*Endamoeba gallinarum*	Ceca	.....	North Atlantic and South Atlantic States, principally.
No common name	*Endolimax gregariniformis*	Ceca	.....	North Atlantic and South Atlantic States, principally.
No common name	*E. numidae*	Ceca	.....	North Atlantic and South Atlantic States, principally.
FLAGELLATES				
No common name	*Trichomonas gallinae*	Crop	.....	Generally distributed thruout North America.
No common name	*T. gallinarum*	Ceca, liver	.....	North Atlantic and South Atlantic States, principally.
No common name	*T. eberthi*	Ceca	.....	Generally distributed thruout North America.
No common name	*T. anseri*	Ceca	.....	Generally distributed thruout North America.
No common name	*Cochlosoma rostratum*	Intestine	.....	California.
No common name	*Hexamita meleagridis*	Intestine	.....	California, Utah.
No common name	*H. columbae*	Intestine	.....	California.
No common name	*Histomonas meleagridis*	Intestine	.....	Generally distributed thruout North America.
SPOROZOA				
Coccidia				
No common name	*Eimeria tenella*	Ceca	.....	Generally distributed thruout North America.
No common name	*E. maxima*	Small intestine	.....	Generally...No. America.
No common name	*E. mitis*	Small intestine	.....	Generally...No. America.
No common name	*E. praecox*	Small intestine	.....	Generally...No. America.
No common name	*E. acervulina*	Small intestine	.....	Generally...No. America.
No common name	*E. meleagridis*	Small intestine	.....	Generally...No. America.
No common name	*E. meleagrimitis*	Small intestine	.....	Generally...No. America.
No common name	*E. labbeana*	Small intestine	.....	Generally...No. America.
No common name	*E. necatrix*	Small intestine	.....	Western States principally, Puerto Rico.
No common name	*E. hagani*	Small intestine	.....	New York.
No common name	*E. brunetti*	Small intestine	.....	New York.
No common name	*E. truncata*	Kidneys	.....	Iowa.
No common name	*Tyzzeria perniciosa*	Small intestine	.....	New York (Long Island).
Haemoproteidae				
No common name	*Haemoproteus columbae*	Blood	Pigeon fly, *Pseudolynchia canariensis*	South Atlantic and South Central States, principally.
No common name	*Leucocytozoon smithi*	Blood	Black flies or Buffalo gnats, *Simulium nigroparvum* *S. occidentale*, *S. venustum*	South Atlantic and South Cental States, Nebraska, California, North Dakota, Minnesota.

Check List of Animal Parasites of Domestic Animals in North America (United States and Possessions, and Canada)

TABLE 11 (Continued).—BIRDS (CHICKENS, TURKEYS, GUINEA FOWL, DUCKS, GEESE AND PIGEONS)—INTERNAL PARASITES

GROUP AND COMMON NAMES	SCIENTIFIC NAMES	LOCATION IN HOST	INTERMEDIATE HOST	GEOGRAPHICAL DISTRIBUTION
Protozoa				
Sporozoa				
Haemoproteidae				
No common name	*L. simondi* (*L. anatis*)	Blood	Black flies or Buffalo gnats *Simulium nigroparvum S. occidentale, S. venustum*	Generally distributed thruout North America.
ORGANISMS OF UNCERTAIN ZOOLOGICAL CLASSIFICATION				
Sarcosporidia	*Sarcocystis rileyi*	Muscles	Unknown	Generally distributed thruout North America.
Trematodes (Flukes)				
SKIN FLUKE	*Collyriclum faba*	Skin	Unknown	Minnesota.
NO COMMON NAME	*Typhlocoelum cymbium*	Respiratory system	Snails, *Menetus planorbis, Helisoma corneus, Lymnea palustris, L. ovata*	Generally distributed thruout North America.
NO COMMON NAME	*Echinostomum revolutum*	Small intestine, ceca, cloaca	Snails of the genera *Planorbis, Helisoma, Lymnaea* and *Pseudosuccinea* and tadpoles	Generally distributed thruout North America.
NO COMMON NAME	*Hypoderaeum conoideum*	Small intestine	Snails of the genera *Planorbis, Helisoma, Lymnaea* and *Pseudosuccinea* and tadpoles	New York.
NO COMMON NAME	*Echinoparyphium recurvatum*	Small intestine	Snails of the genera *Planorbis, Helisoma, Lymnaea* and *Pseudosuccinea* and tadpoles	Generally distributed thruout North America.
NO COMMON NAME	*Ribeiroia ondatrae*	Proventriculus	Snails, *Helisoma antrosum percarinatum* and fishes, perch, *Perca flavescens*, rock bass, *Amblopites rupestris*, small mouth black bass, *Micropterus dolomieu*, bluegill, *Lepomis pallidus*, pumpkin seed, *Eupomotis gibbosus*	Colorado.
NO COMMON NAME	*Sphaeridiotrema globulus*	Small intestine, Ceca	Unknown	Oregon.
NO COMMON NAME	*Cotylurus flabelliformis*	Intestine	Snails of the genera *Helisoma, Planorbis, Stagnicola, Lymnaea* and *Physa*	Michigan.
NO COMMON NAME	*Strigea falconis*	Viscera	Unknown	Texas.
NO COMMON NAME	*Postharmostomum gallinum*	Ceca	Snails, *Eulota similaria* and *Subulina octona*	Hawaii, Puerto Rico.
NO COMMON NAME	*Notocotylus imbricatus*	Rectum, ceca	Snails of the genera *Lymnaea* and *Physa*	Oregon, New York.
NO COMMON NAME	*Paramonostomum parvum*	Intestine	Unknown	New York.
NO COMMON NAME	*Zygocotyle lunata*	Ceca	Snails, *Helisoma antrosum*	Generally distributed thruout North America.
NO COMMON NAME	*Amphimerus* sp.	Liver	Unknown	North Dakota.
NO COMMON NAME	*Tamerlanea bragai*	Kidneys	Unknown	Puerto Rico.
NO COMMON NAME	*Prosthogonimus macrorchis*	Oviduct, Bursa fabricii	Snails, *Amnicola limosa porata* and dragon flies genera *Leucorrhinia, Tetragoneuria* and *Epicordulia* and *Mesothemis*	States bordering Great Lakes, Louisiana.

Check List of Animal Parasites of Domestic Animals in North America (United States and Possessions, and Canada)

TABLE 11 (Continued).—BIRDS (CHICKENS, TURKEYS, GUINEA FOWL, DUCKS, GEESE AND PIGEONS)—INTERNAL PARASITES

GROUP AND COMMON NAMES	SCIENTIFIC NAMES	LOCATION IN HOST	INTERMEDIATE HOST	GEOGRAPHICAL DISTRIBUTION
Cestodes (Tapeworms)				
NO COMMON NAME	*Davainea proglottina*	Small intestine	Slugs, *Agriolimax agrestis*	Generally distributed thruout North America.
NO COMMON NAME	*D. meleagridis*	Small intestine	Unknown	District of Columbia.
NO COMMON NAME	*Amoebotaenia sphenoides*	Small intestine	Earthworms, *Helodrilus foetidus, Pheretina pequana, Allolobrophora chloritica*	Michigan, Texas, Kansas, Puerto Rico.
NO COMMON NAME	*Hymenolepis carioca*	Small intestine	Beetles, *Anisotarsus agilis, Aphodium granarius, Choeridium histeroides;* stable fly, *Stomoxys calcitrans*	Generally distributed thruout North America.
NO COMMON NAME	*H. cantaniana*	Small intestine	Dung beetles, *Aetenius cognatus, A. stercorator, Choeridium histeroides*	Eastern United States, Puerto Rico.
NO COMMON NAME	*H. compressa*	Small intestine	Unknown	.....
NO COMMON NAME	*H. exigua*	Small intestine	Sandhoppers, *Orchestia platensis*	Hawaii.
NO COMMON NAME	*Raillietina cesticillus*	Small intestine	Beetles, *Amara* spp., *Anaferonia* spp., *Anisotarsus* spp., and many others	Generally distributed thruout North America.
NO COMMON NAME	*R. tetragona*	Small intestine	Ants, *Tetramorium caespitum, Pheidole vinelandica*	Generally distributed thruout North America.
NODULAR TAPEWORM	*R. echinobothrida*	Small intestine	Ants, *Tetramorium caespitum, Pheidole vinelandica*	Generally distributed thruout North America.
NO COMMON NAME	*R. magninumida*	Snall intestine	Ground beetle, *Selenophorus pedicularis*	Eastern United States.
NO COMMON NAME	*Choanotaenia infundibulum*	Small intestine	House fly, *Musca domestica;* ground and dung beetles, *Amara fallax, Anaferonia constricta, Cratacanthus dubius, Aphodius granarius* and others. Grasshoppers, *Melanoplus femurrubrum, Dicromorpha viridis*	Generally distributed thruout North America.
COMMON TAPEWORM OF TURKEYS	*Metroliasthes lucida*	Small intestine	Grasshoppers, *Melanoplus* sp. *Chorthippus curtipennis, Paroxya clavuliger*	Generally distributed thruout North America.
PIGEON TAPEWORM	*Aporina delafondi*	Small intestine	Unknown	South Atlantic and South Central States.

Check List of Animal Parasites of Domestic Animals in North America (United States and Possessions, and Canada)

TABLE 11 (Continued).—BIRDS (CHICKENS, TURKEYS, GUINEA FOWL, DUCKS, GEESE AND PIGEONS)—INTERNAL PARASITES

GROUP AND COMMON NAMES	SCIENTIFIC NAMES	LOCATION IN HOST	INTERMEDIATE HOST	GEOGRAPHICAL DISTRIBUTION
Nematodes(Roundworms)				
MANSON'S EYEWORM	*Oxyspirura mansoni*	Eye	Cockroach, *Pycnoscelus surinamensis*	Florida, Louisiana.
GAPEWORM	*Syngamus trachea*	Trachea	Earthworms, *Helodrilus foetidus, H. caliginosus* may serve as mechanical carriers	Irregularly distributed thruout North America.
CROPWORMS	*Capillaria annulata*]	Esophagus, crop	Earthworms, *Helodrilus foetidus, H. caliginosus*	Generally distributed thruout North America.
	C. contorta	Esophagus, crop	.....	Generally distributed thruout North America.
CHICKEN GULLET WORM	*Gongylonema ingluvicola*	Crop	Unknown	Maryland, District of Columbia, Florida.
BIRD STOMACH WORM	*Dispharynx spiralis*	Proventriculus	Pill-bug, *Armadillidium vulgare*, Sowbug, *Porcellio scaber* (Experimental)	Generally distributed thruout North America.
GLOBULAR STOMACH WORMS OF BIRDS	*Tetrameres americana*	Proventriculus	Grasshoppers, *Melanoplus femurrubrum, M. differentialis*, cockroach, *Blatella germanica*	Irregularly distributed thruout North America.
	T. crami	Proventriculus	Amphipods, *Gammarus fasciatus, Hyalella knickerbockeri*	Canada (Ontario and Quebec in domestic ducks; Eastern and Mid-western Canada in wild ducks).
CHICKEN GIZZARD WORM	*Cheilospirura hamulosa*	Gizzard	Flour beetle, *Tenebroides nana* and sandhopper, *Orchestia platensis* found naturally infected in Hawaii. Various species of grasshoppers, flour, ground and dung beetles and weevils experimentally infected	Generally distributed thruout North America.
DUCK GIZZARD WORM	*Amidostomum anseris*	Gizzard	.....	Generally...No. America.
LARGE INTESTINAL ROUNDWORMS	*Ascaridia galli*	Small intestine	.....	Generally...No. America.
	A. columbae	Small intestine	.....	Generally...No. America.
	A. numidae	Small intestine	.....	Louisiana, Puerto Rico.
NO COMMON NAME	*Capillaria caudinflata*	Small intestine	Earthworms	North and South Atlantic and North and South Central States.
NO COMMON NAME	*C. columbae*	Small intestine	.....	Generally distributed thruout North America.
NO COMMON NAME	*Trichostrongylus tenuis*	Small intestine	.....	District of Columbia.
NO COMMON NAME	*Ornithostrongylus quadriradiatus*	Small intestine	.....	Generally distributed thruout North America.
CECAL WORMS	*Heterakis gallinae*	Ceca	.....	Generally distributed thruout North America.
	H. brevispiculum	Ceca	.....	Puerto Rico.
	Subulura brumpti	Ceca	Beetles, *Dermestes vulpinus, Gonocephalus seriatum, Ammaphorus insularis, Alphitobius diaperinus;* Earwigs *Euborellia annulipes*	Puerto Rico, Panama (Canal Zone). Hawaii.
	S. strongylina	Ceca	Unknown	Puerto Rico.
NO COMMON NAME	*Strongyloides avium*	Ceca	.....	South Atlantic States, Louisiana, Puerto Rico.

Check List of Animal Parasites of Domestic Animals in North America (United States and Possessions, and Canada)

TABLE 12.—BIRDS (CHICKENS, TURKEYS, DUCKS, GEESE, GUINEA FOWL AND PIGEONS)—EXTERNAL PARASITES

GROUP AND COMMON NAMES	SCIENTIFIC NAMES	LOCATION IN HOST	INTERMEDIATE HOST	GEOGRAPHICAL DISTRIBUTION
Arthropods				
TICKS				
Chicken tick (Blue bug)	*Argas persicus*	External	.....	Florida, Georgia, Louisiana, Texas, Oklahoma, New Mexico, Arizona, Utah, California.
No common name	*Ornithodoros talaje* (Larvae)	External	.....	Panama (Canal Zone).
Rabbit tick	*Haemaphysalis leporis-palustris* (Nymphs)	External	.....	Iowa.
No common name	*H. cinnabarina*	External	.....	Canada.
FLEAS				
Sticktight flea	*Echidnophaga gallinacea*	Eyes, wattles, and comb	.....	Southern States principally, Puerto Rico, Hawaii, and Panama (Canal Zone).
European chicken flea	*Ceratophyllus gallinae*	External	.....	Eastern United States and Southeastern Canada.
Western chicken flea	*C. niger*	External	.....	Alaska, western parts of Canada, and United States.
Human flea	*Pulex irritans*	External	.....	Montana.
Cat flea	*Ctenocephalides felis*	External	.....	(Trembley and Bishopp, 1940, Locality not stated).
LICE				
Biting lice				
Head louse	*Lipeurus heterographus*	Head	.....	Generally distributed thruout North America.
Wing louse	*L. caponis*	Wing feathers	.....	Generally distributed thruout North America.
Slender turkey louse	*L. gallipavonis*	Feathers	.....	Generally distributed thruout North America.
Tropical head louse	*L. angularis*	Head	.....	Panama (Canal Zone).
No common name	*L. bishoppi*	Wing feathers	.....	Mississippi.
No common name	*L. numidae*	.....	.....	Puerto Rico.
Body louse	*Eomenacanthus stramineus*	Body	.....	Generally distributed thruout North America.
Large body louse	*Menacanthus latus*	Body at base of rump feathers, base of large pin feather (flight or tail feathers)	.....	.....
Shaft louse	*Menopon gallinae*	Shaft of feathers	.....	Generally distributed thruout North America.
Fluff louse	*Goniocotes hologaster*	Fluff of feathers	.....	Generally distributed thruout North America.
Large chicken louse	*G. gigas*	Feathers	.....	Generally distributed thruout North America. (Rare in Canada).
Small pigeon louse	*Goniocotes bidentatus*	Feathers	.....	Generally distributed thruout North America.
Brown chicken louse	*Goniodes dissimilis*	Feathers	.....	Southern United States.

Check List of Animal Parasites of Domestic Animals in North America (United States and Possessions, and Canada)

TABLE 12 (Continued).—BIRDS (CHICKENS, TURKEYS, GUINEA FOWL, DUCKS, GEESE AND PIGEONS)—EXTERNAL PARASITES

GROUP AND COMMON NAMES	SCIENTIFIC NAMES	LOCATION IN HOST	INTERMEDIATE HOST	GEOGRAPHICAL DISTRIBUTION
Arthropods				
LICE				
Biting lice				
Large turkey louse	*Goniodes meleagridis*	Feathers	.....	Generally distributed thruout North America.
Little feather louse	*Goniodes damicornis*	Feathers	.....	.....
Slender pigeon louse	*Columbicola columbae*	Feathers	.....	Generally distributed thruout North America.
Narrow body louse	*Colpocephalum turbinatum*	.....	.....	South Carolina, Florida, Panama (Canal Zone).
Narrow body louse	*Colpocephalum* sp.	.....	.....	Puerto Rico.
No common name	*Anatoecus dentatus*	Feathers	.....	Southern United States. Canada (Quebec).
No common name	*Anaticola crassicornis*	Feathers	.....	Southern United States. Canada (Quebec).
MITES				
Chicken mite	*Dermanyssus gallinae*	Skin	.....	Widely distributed thruout North America.
Feather mite	*Liponyssus sylviarum*	Feathers about tail, vent and neck	.....	Widely distributed thruout North America.
Tropica feather mite	*L. bursa*	Skin	.....	South Atlantic and South Central States principally, Puerto Rico, Panama (Canal Zone).
Scaly-leg mite	*Cnemidocoptes mutans*	Legs, comb and neck	.....	Widely distributed thruout North America.
Depluming mite	*Cnemidocoptes gallinae*	Skin near base of feathers	.....	Widely distributed thruout United States.
Flesh mite	*Laminosioptes cysticola*	Skin	.....	New York, Colorado, District of Columbia.
Skin mite	*Epidermoptes bilobatus*	Skin	.....	Illinois.
Quill mite	*Syringophilus bipectinatus*	Feathers	.....	Generally distributed thruout United States.
Wing feather mite	*Falculifer rostratus*	Flight and wing feathers	.....	Texas, South Carolina, Louisiana; Canada (British Columbia).
Air sac mites	*Cytoleichus nudus*	Air sacs	.....	District of Columbia, Puerto Rico.
No common name	*Freyana chanayi*	Shaft of wing feathers	.....	Maryland, Texas, and Louisiana.
No common name	*Megninia cubitalis*	Shaft of wing feathers	.....	Texas, Louisiana, Puerto Rico.
No common name	*M. columbae*	Neck and body feathers	.....	South Carolina.
Chigger or Harvest mite	*Eutrombicula alfreddugesi*	Skin	.....	Widely distributed thruout North America, most abundant in South Atlantic and South Central States.
Chicken chigger	*Neoschongastia americana*	Skin	.....	Southern States.
FLIES				
Pigeon fly	*Pseudolynchia canariensis*	Skin	.....	South Atlantic and South Central States, principally.

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Studies on Swine Enteritis
II. Salmonella and Other Enteric Organisms Isolated from Diseased and Normal Swine

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THE etiology of infectious or necrotic enteritis unassociated with hog cholera may apparently stem from different causes. In addition to bacterial agents of etiologic significance, nutritional deficiencies are recognized as possible predisposing or primary exciting agents of a clinical syndrome marked by fever, inappetence, emaciation, and diarrhea. Autopsy of affected animals discloses necrotic inflammatory processes of the colon. Since the necrotic lesions of the enteritis complex are not pathognomonic, it remains to be established with certainty that bacterial and nutritional factors operating independently or as collaborating etiologic agents induce indistinguishable, gross enteric lesions.

Murray, Biester, Purwin, and McNutt,[1,2] Biester, Murray, McNutt and Purwin,[3] and Biester[4] clearly demonstrated the pathogenicity of *Salmonella choleraesuis* for swine and described the experimental infection as being indistinguishable from the naturally occurring disease. Necrotic lesions in the intestine have been observed in experimental pigs fed large amounts of *S. choleraesuis* and *Salmonella typhimurium* at the Illinois Agricultural Experiment Station while, on occasion, experimental pigs proved resistant to the feeding of mass cultures of Salmonella. McBryde[5] described a severe outbreak of scours in suckling pigs as being due to the colon bacillus, and in a second report McBryde[6] found *S. choleraesuis* to be associated with enteritis and pneumonia in pigs of corresponding age. Whiting confirmed the pathogenicity of *S. choleraesuis* for pigs but found the experimental disease not to be identical with the sporadic disease termed dysentery.

More recent investigations tend to cast doubt upon the primary etiological relationship of Salmonella organisms as an exclusive and primary cause of the swine-enteritis complex. McEwan[7] failed to associate an outbreak of necrotic enteritis with any specific organism and at the same time excluded cholera and parasitic infections as probable etiological factors. Hindmarch, Stewart, and Hart[8] concluded from serological studies that *S.*

TABLE 1—Enteric Organisms Isolated from the Viscera and Colon of 227 Swine Presented for Postmortem Examination

Enteric Group Present	Gross Intestinal Lesions				Total	
	Present		Absent			
	Pigs	%	Pigs	%	Pigs	%
Salmonella species	21	17.1	9	8.7	30	13.2
Nongas formers (Eberthella-like and Shigella-like)	19	15.4	17	16.3	36	15.9
Proteus species	17	13.8	4	3.8	21	9.3
Paracolon organisms	70	56.8	39	37.5	109	48.0
Slight gas formers	46	37.4	20	19.2	66	29.3
One or more of the above five groups present	98	79.7	64	61.5	162	71.4
None of the above five groups present	25	20.3	40	38.5	65	28.6

The distribution of these organisms within the animal body is set forth in table 2.

Captain Norman D. Levine, Sn. C., A.U.S., initiated this investigation while Drs. Peterson and Graham, of the Department of Animal Pathology and Hygiene, University of Illinois, Urbana, carried the work to completion and arranged the data for publication.

choleraesuis, var. *kunzendorf* is not the primary cause of swine enteritis. Dimock and Edwards,[9] of the Kentucky Agricultural Experiment Station, as a result of long experience with Salmonella organisms, express the opinion that these bacteria are not the primary cause of porcine necrotic enteritis.

Doyle[10-12] differentiates swine dysentery as a disease distinct from necrotic enteritis. In outbreaks of enteritis, he has frequently incriminated hog cholera virus. Whiting[13] previously referred to and Hofferd[14] also differentiate between necrotic enteritis and dysentery of swine.

Chick, Macrae, Martin, and Martin[15] demonstrated that swine enteritis can be initiated by nutritional factors. There has since arisen an increasingly extensive literature on nutritional deficiencies in their relationships to enteric disorders of swine (Hughes[16]; Madison, Miller, and Keith[17]; Davis, Freeman, and Madsen[18]; Davis, Hale, and Freeman[19]; Wintrobe, *et al.*[20]; Worden and Slavin[21]).

The observations reported herein concern data on the isolation and pathogenicity of Salmonella and other enteric organisms isolated from swine presented for diagnosis during the past four years at the Department of Animal Pathology and Hygiene, University of Illinois. The first portion of the investigation involved a study of the aërobic, asporogenous, gram-negative rods obtained from the intestinal tracts and viscera of 227 pigs. Of these animals, 123 showed gross lesions of the intestinal tract. However, none of the swine was regarded as normal since all were presented for autopsy. Diagnoses included such diseases as hog cholera, swine erysipelas, ascariasis, necrotic enteritis, dysentery, etc.

Bacteriological examinations consisted of direct cultures from the liver, spleen, and heart blood upon MacConkey's agar. Material from the colon was streaked upon SS agar, and cultured in tetrathionate broth, growth from the latter being subsequently streaked upon MacConkey's medium. Selected colonies were picked into tubes of Russell's double sugar agar in order to eliminate colon bacilli from the collection. Retained cultures were checked for purity and differentiated into groups according to the following cultural characteristics: fermentation of carbohydrates (dextrose, lactose, maltose, sucrose, arabinose, galactose, inulin, dulcitol, levulose, mannitol, raffinose, rhamnose, sorbitol, trehalose, xylose, salicin, inositol, adonitol, cellobiose, and glycerol), indol formation, the methyl red test, the Voges-Proskauer reaction, nitrate reduction, gelatin liquefaction, utilization of citrate as the sole source of carbon as determined by Koser's citrate medium, hydrogen sulfide production, motility, and colony morphology.

The organisms studied were divided into five groups on the basis of the differential tests. These were Salmonella species, nongas formers (Eberthella-like and Shigella-like species), members of the genus Proteus, paracolon organisms, and a fifth grouping of bacteria not fitting with certainty into any of the established classes of the enteric group and characterized by the formation of a bubble or at most 10 per cent of gas from the sugars which they attacked. This group was termed "slight gas formers."

TABLE 2—Frequency of Isolation of the Organisms Listed in Table I in the Colon and Viscera (Liver, Spleen, and Heart Blood)

Enteric Group Present	Source	Number of Pigs: Gross Intestinal Lesions Present	Gross Intestinal Lesions Absent	Total
Salmonella species	Viscera	8	2	10
	Colon	15	6	21
Nongas formers (Eberthella-like, Shigella-like)	Viscera	1	1	2
	Colon	18	16	34
Proteus species	Viscera	0	0	0
	Colon	17	4	21
Paracolon organisms	Viscera	7	4	11
	Colon	65	36	101
Slight gas formers	Viscera	2	2	4
	Colon	46	20	66

The frequency isolation of bacteria classified in the five groups from the 227 swine examined is set forth in table 1.

Of Salmonella strains listed in tables 1 and 2 and identified according to species by Dr. P. R. Edwards, of the Kentucky Agricultural Experiment Station, 10 were found to be *S. choleraesuis*, var. *kunzendorf*, 3 were *S. typhimurium*, and there was 1 each of *Salmonella panama*, *Salmonella give*, *Salmonella bredeney*, *Salmonella bareilly*, *Salmonella urbana*, and *Salmonella illinois*. Only *S. choleraesuis*, var. *kunzendorf* was isolated from the viscera, all other species in this genus originating from the colon.

As a result of these findings, it might be inferred that with the exception of *S. choleraesuis*, var. *kunzendorf*, all other species and types of microörganisms listed in table 2 are probably primarily intestinal forms.

PATHOGENICITY TRIALS

A total of 22 healthy weanling pigs were exposed *per os* to varying quantities of organisms from each of the five groups. Sixteen of the pigs were given broth cultures of selected strains by means of a stomach tube, while the remaining 6 were exposed by the feeding of dead pigeons and guinea pigs which had succumbed to infections with identified Salmonella species. The results are given in table 3.

Pathogenicity for swine was demonstrated for *S. choleraesuis*, var. *kunzendorf* and perhaps for *S. typhimurium*. Because of the enormous exposures used and the small number of pigs employed, these results, however, should not be interpreted as indicating proved pathogenicity of these two organisms for swine under field conditions. The organisms studied, including *S. bareilly*, *S. give*, *S. illinois*, Eberthella-like, Shigella-like, Proteus and Paracolon species and the group termed slight gas formers, proved to be under the conditions of these trials entirely innocuous to swine even with heavy exposure.

Isolation of Salmonella Organisms from Diseased and Normal Swine.—The various types of Salmonella organisms isolated from swine presented for diagnosis during the past four years are shown in table 4. The Salmonella isolations listed in table 1 are included also. Information as to the source of the organism within the body is not given as the intestinal contents and viscera were not cultured in parallel in all cases.

The species of Salmonella organisms isolated from the feces of normal breeding sows are shown in table 5.

Although the number of fecal specimens from normal swine examined was limited, the isolation of seven Salmonella species

TABLE 3—Pathogenicity for Weanling Pigs of Selected Strains of Salmonella and Other Enteric Organisms

ORGANISM OR GROUP	PIG NO.	EXPOSURE*	RESULTS
Salmonella choleraesuis var. *kunzendorf*	1	800 cc. broth culture	Died in nine days.
	2	2,000 cc. broth culture	Sickened but recovered.
	3	10 pigeons and guinea pigs	Sickened but recovered.
	4	10 pigeons and guinea pigs	Unaffected.
Salmonella typhimurium	5	2,000 cc. broth culture	Sickened but recovered.
	6	10 pigeons and guinea pigs	Unaffected.
Salmonella bareilly	7	2,000 cc. broth culture	Unaffected.
	8	10 pigeons and guinea pigs	Unaffected.
Salmonella give	9	2,000 cc. broth culture	Unaffected.
	10	10 pigeons and guinea pigs	Unaffected.
Salmonella illinois	11	10 pigeons and guinea pigs	Unaffected.
Eberthella-like sp.	12	50 cc. broth culture	Unaffected.
Shigella-like sp.	13	50 cc. broth culture	Unaffected.
Proteus sp.	14	50 cc. broth culture	Unaffected.
	15	50 cc. broth culture	Unaffected.
Paracolon sp.	16	50 cc. broth culture	Unaffected.
	17	50 cc. broth culture	Unaffected.
	18	2,000 cc. broth culture	Unaffected.
Paracolon and Proteus sp.	19	2,000 cc. broth culture of each organism	Unaffected.
Slight gas formers	20	50 cc. broth culture	Unaffected.
	21	50 cc. broth culture	Unaffected.
	22	2,000 cc. broth culture	Unaffected.

*Broth inoculation in excess of 50 cc. given in daily doses of 200 cc. each.

TABLE 4—Isolation of Salmonella Organisms from Diseased Swine

SALMONELLA SPECIES*	TOTAL ISOLATIONS
Salmonella choleraesuis, var. *kunzendorf*	134
Salmonella choleraesuis	3
Salmonella typhimurium	16
Salmonella bredeney	15
Salmonella worthington	7
Salmonella derby	2
Salmonella give	3
Salmonella bareilly	2
Salmonella oranienburg	1
Salmonella newport	4
Salmonella urbana	2
Salmonella illinois	1
Salmonella panama	2
Salmonella anatum	1
Salmonella cerro	1
Total	194

*All Salmonella species referred to in this paper were identified through the courtesy of Dr. P. R. Edwards, of the Kentucky Agricultural Experiment Station.

from the feces of 38 normal swine would indicate that the incidence of this bacterial group in the intestinal tract of normal swine may be considerable. Rubin, Scherago, and Weaver[22] isolated 13 species of Salmonella organisms from the mesenteric lymph glands of normal swine slaughtered at abattoirs. The incidence of isolation was about 5 per cent.

AGGLUTINATION STUDIES

The agglutination titers of 110 swine-blood serum samples as determined with "H" antigens prepared from *S. choleraesuis*, var. *kunzendorf*, *S. bredeney*, and *S. typhimurium* are shown in table 6. Most of these pigs were presented for the diagnosis of disease and approximately one-third of them showed gross lesions of the lower intestinal tract.

Although many of these pigs were suffering from clinical enteritis of the form commonly known as "necro" or necrotic enteritis, the "H" antigen agglutination titers are all within the limits of normal swine blood as determined by Lovell.[23,24] As a result of experimental exposures with *S. choleraesuis*, var. *kunzendorf*, Hindmarch, Stewart, and Hart[9] demonstrated that porcine infections with this organism, even when of a subclinical nature, are associated with a rapid increase in the "H" agglutinins in the blood, the maximum titer obtained being 1:1,280, the minimum 1:320. Consequently the "H" antigen agglutination reactions of the swine bloods listed in table 6 do not indicate that any of these animals were suffering from infection with any of the three Salmonella organisms listed.

SUMMARY

In a study of 227 swine presented for autopsy and diagnosis, approximately 55 per cent of which showed gross inflammatory lesions of the lower intestinal tract, Salmonella organisms were isolated from 30 or 13 per cent of the total and from 21 or 17 per cent of those showing gross intestinal lesions. Organisms classifying in other genera of the enteric group, namely, nongas formers (Eberthella-like and Shigella-like species), members of the Proteus and Paracolon groups, and a further group not classified according to genus, were isolated from 153 of these swine. Organisms from the five enteric groups were not isolated from 65, or 29 per cent of the total number of pigs. Of these 65 animals, 25 or a little over 38 per cent, showed gross lesions of the lower digestive tract.

Salmonella choleraesuis, var. *kunzendorf*, was the only organism isolated with consistency from the viscera. It is indicated, therefore, that of all bacterial groups and species, this organism may be the only one with marked invasive powers, and that the other species of Salmonella and the groupings of the enteric organisms found, may represent primarily intestinal forms, perhaps normal to the healthy porcine digestive tract.

The pathogenicity of *S. choleraesuis* var. *kunzendorf* and *Salmonella typhimurium* was demonstrated by feeding large amounts

TABLE 5—Species of Salmonella Organisms Isolated from the Feces of 38 Healthy Brood Sows

SALMONELLA SPECIES	TOTAL ISOLATIONS
Salmonella bredeney	2
Salmonella give	2
Salmonella kentucky	1
Salmonella senftenburg	1
Salmonella oranienburg	1
Salmonella panama	1
Salmonella cerro	1

of the culture. These experimental observations on pathogenesis do not exclude other possible etiologic factors in sporadic enteritis in swine.

cent were *S. choleraesuis*, var. *kunzendorf*. The remaining 60 isolations consisted of a grouping of 14 Salmonella species.

The "H" antigen agglutination titers of

TABLE 6—"H" Antigen Agglutination Titers of 110 Samples of Swine Blood Gross Lesions in the Lower Digestive Tract Were Present in Approximately One Third of the Corresponding Pigs

Agglutination Titer	Number of Serum Samples Showing Reactions with Antigens Prepared from the Following Salmonella Species:		
	Salmonella choleraesuis var. kunzendorf	Salmonella bredeney	Salmonella typhimurium
No reaction	58	48	55
1:10	22	15	17
1:20	16	17	18
1:40	9	22	13
1:80	5	6	7
1:160	0	2	0

Salmonella bareilly, Salmonella give, Salmonella illinois, Eberthella-like, Shigella-like, Proteus, and Paracolon species and the unclassified group termed "slight gas formers" proved nonpathogenic to pigs following large doses by the mouth.

Of 194 strains of Salmonella organisms isolated from swine submitted for autopsy over a period of four years, 134 or 69 per

110 swine blood serum samples did not indicate that any of the corresponding animals were suffering or had suffered from active infection with *Salmonella choleraesuis*, var. *kunzendorf*, *Salmonella bredeney*, or *S. typhimurium*. Most of these pigs were submitted for autopsy and approximately one third of them showed gross lesions of the lower digestive tract.

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An Active Agent Isolated from Hogs Affected with Arthritis (Preliminary Report)

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THE FOLLOWING is a preliminary report on an apparently new active agent which is pathogenic for swine. Grey, Osteen, and Schoening[1] isolated *Erysipelothrix rhusiopathiae* from about 75 per cent of the cases of arthritis in market hogs. From this, it has been concluded that *E. rhusiopathiae* is the cause of arthritis in a great majority of cases involving hogs of this age. In an investigation of arthritis of younger pigs in Iowa, an extremely high incidence of swine erysipelas was not found. The swine-erysipelas organism was isolated from only about one fourth of the cases involving pre-slaughter-age pigs. Streptococci and staphylococci were isolated from a like number of cases. Scattered cases of pyemia were encountered. That no infection was found in most of the remainder was baffling because many appeared to be caused by infection. These showed congestion and hemorrhage of the joint capsules together with an increased amount of joint fluids which were thick, turbid, and often blood-tinged. In the older more chronic cases, the lesions were associated with thickening of the connective tissue structures about the affected articulations, but there was no erosion of the articular surfaces, which might indicate a nutritional deficiency. Also, these herds were properly fed and cared for, which again indicated that faulty husbandry was not to blame. All in all, the lesions were indistinguishable from those caused by *E. rhusiopathiae*. When the inflammatory exudates from the diseased articulations were inoculated on laboratory mediums or into the usual laboratory animals, no evidence of bacteria or other infection was obtained. It was tentatively concluded that the causal agent differed from the usual bacteria and that it was nonpathogenic for laboratory animals. A search was made for such an infective agent with the result that one has been recently discovered. Furthermore, the agent appears to be entirely new, hitherto undescribed.

A single herd under our supervision provided material. There was considerable arthritis among the weaned spring pigs in the herd, and it was found that some of the affected pigs reacted to the agglutination test for swine erysipelas; whereas others did not. Three affected pigs were obtained from the herd for study. Two of the pigs reacted to the erysipelas test and 1 did not. The swine-erysipelas organism was readily isolated from the affected joints of both reactor pigs, but no bacteria were obtained from the nonreactor. The inflammatory exudate from the articulations of the nonreactor was carefully collected, and then injected into 7-day-old, chicken embryos. An active agent was isolated from the embryos. The question then arose as to whether the active agent came from a natural infection of the embryos themselves or whether it was carried in the original inoculum. Eighty per cent of the original inoculated embryos was shown to contain the agent, and it increased or multiplied in these embryos. Those who work with chicken embryos will recognize that 80 per cent is a very high incidence of takes, higher than is usually obtained with first inoculations of equine encephalitis, which is perhaps the easiest known virus to establish in embryos. In our experience, no natural infection has been found in eggs that will produce such a high percentage of accidental or false takes in original inoculations. In this regard, we have experienced

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what seems to be contamination with the virus first reported by Waller,[2] the possible cause of "blue comb" in chickens. Waller, Tepper, Halpin, and Davis[3] reported a high incidence of egg infection from flocks in which blue comb was active. In a careful examination of more than 10,000 embryos, we have found what seems to be blue comb virus in only two instances, in 2 embryos. Thus, it is fairly obvious that the active agent under study was actually present in the joint exudates of the swine and that it was propagated in the embryos. Laboratory animals were exposed to the agent. White mice were inoculated subdurally, intraperitoneally, and intranasally. Guinea pigs were inoculated subcutaneously, intramuscularly, intraperitoneally (in series), and subdurally. Rabbits were inoculated subdurally, intramuscularly, and intraperitoneally. All of these exposures were apparently negative. More recently, mice that have been exposed intranasally in series have developed pneumonia on the third passage. Tests are now in progress to determine whether this is an actual infection with the agent or whether the pneumonia is an occult, natural infection already present in the mice. In this regard, tests conducted in the past have shown that the stock mice did not carry a natural infection capable of producing pneumonia or any other infection that could be demonstrated.

The question next arose as to whether the agent was one that actually produced the hog disease or whether it was one that was accidentally passing through an already diseased articulation. To obtain an answer, experimental hogs were injected.

The preliminary swine inoculations were on a trial and error basis since it was necessary to learn how pigs should be exposed. Of 4 pigs injected subcutaneously, 3 showed lameness and the active agent was recovered from all 3, while the fourth pig was apparently negative. One of the positive pigs was killed six days after inoculation, and the agent was isolated from the point of inoculation; a second was killed twelve days after inoculation, and the agent was isolated from the lymph glands draining the area of inoculation, while the third was killed twelve days after inoculation, and it showed lesions typical in field cases, and the agent was recovered from the right hip joint.

There was no evidence of paralysis, involvement of the nerves, in any of the field cases or artificially produced cases; nevertheless, attempt was made to infect pigs by intracerebral injection. Three such pigs were employed. The first died of accidental streptococcus meningitis within twenty-four hours. The agent was recovered from the brain of this pig. The second pig developed incoördination eight days after injection from which it gradually but only partially recovered. It was thought that the condition in this pig was due to mechanical injury, not to infection. The third pig passed through an early, moderately severe reaction but soon recovered. It was tentatively concluded that the agent was not neurotropic. A single pig, injected intrapleurally, developed a severe cough of several days duration, but otherwise showed no symptoms of disease. In the light of later experiences, this method of exposure is again being tried.

Two pigs were injected intraperitoneally with the agent that had originally been isolated in embryos from a field case, passed through an experimental pig, and again recovered in embryos. Both pigs became inactive, lost weight, ate but little, and developed severe lameness. Their temperatures were usually within a normal range but sometimes reached 103 to 104 F. One of these pigs was killed six days after inoculation. There was an exudate over the large intestine and omentum. This exudate was in the form of light cream-colored strands and flat irregular pieces. There was slight evidence of adhesions of the liver to the diaphragm and numerous small areas of redness under the parietal peritoneum. The condition in the pleural cavity resembled that in the peritoneal, although the character of the pleural exudate was more puslike. On preliminary examination, there seemed to be no pneumonia. The heart, liver, spleen, and kidneys seemed normal. The right hip joint, both hock joints, and the left knee joint all showed extensive in-

flammation. Attempts to isolate the active agent from the pleural exudate, spleen, and peritoneal exudate were successful. Results with the urine and pericardial fluids were negative, although positive in pigs inoculated later.

In these preliminary experiments, the intraperitoneal method of exposure seemed to produce the more severe type of disease, with more lameness and a larger number of articulations involved. The second pig injected intraperitoneally, as mentioned previously, was killed twenty-one days later. It still moved slowly as if in pain and all four legs seemed to be affected. The animal was beginning to eat more at this time and was thought to be recovering. On postmortem examination, there were three areas of peritonitis 3 to 4 inches in diameter in which there were very firm adhesions. The remains of a yellow exudate were incorporated in these areas. The spleen was normal in size but showed one small torn area under the capsule. The right hip, right shoulder, left shoulder, and left hock joints showed typical lesions—redness of the joint capsule and hemorrhage into the thick joint exudate which in no case was very abundant. One joint capsule showed an acutely inflamed ulceration.

Following the previously mentioned preliminary inoculations, there was a delay of several months during which the active agent was propagated in chicken embryos, and no swine passages were made. When swine passage was again attempted, it was found that the active agent had lost much of its pathogenicity for swine, apparently because it had been propagated for a considerable time in embryos only. However, a single passage through pigs again brought the agent to its original pathogenicity, and subsequent passages greatly increased its virulence until very serious symptoms are now produced when pigs are inoculated. Transmission through pigs by intraperitoneal inoculation, and perhaps propagation on chicken embryos, has apparently caused the active agent to change in one respect. It now has a strong affinity or predilection for the serous membranes where severe inflammation is set up. It is hoped that the experiments in swine transmission now in progress can be completed and reported in the near future.

The affinity of the infectious agent for the serous membranes suggested that it might be related to the influenza viruses, especially swine-influenza virus, or that it might have become accidentally contaminated with swine-influenza virus through animal passage. To test these possibilities in a preliminary way, mice are being inoculated intranasally in series, and the agent has been tested for its ability to agglutinate check red blood cells. The mouse tests have not been completed but there is preliminary evidence that mice can be infected. In the agglutination of chicken red blood cells, the method of Salk[4] was employed. Negative controls in these tests consisted of blanks containing red cells in physiological salt solution as well as suspensions of viruses known not to cause agglutination. Positive controls were set up with a known strain of swine influenza and the Lee strain of type B human influenza. The negative controls were all sharply negative in all dilutions, the positive controls were all sharply positive in high dilutions, and the experimentals were all negative in dilutions of 1:20 to 1:10,000. When compared to swine-influenza virus in chicken embryos, the arthritis agent is much less active. Thus, presumptive evidence has been obtained that the arthritis agent is not influenza virus or even closely related to the influenza viruses.

It will be noted that the arthritis agent was isolated from a herd of hogs which was also affected with swine erysipelas. It has been shown that the injection of the swine-erysipelas organism into swine, especially repeated injections, often results in arthritis. We have shown that this agent can produce arthritis and that such arthritis is not associated with swine erysipelas. There was the possibility that the two diseases might supplement each other so that infection with both diseases would be much more severe than either alone. To test this possibility, cultures of virulent *E. rhusiopathiae* were mixed with a suspension of the arthritis agent and the mixture in-

jected intraperitoneally into 2 pigs. The disease produced was no more severe than that produced by the arthritis agent alone. One of these pigs was killed six days later and the other eight days later. *E. rhusiopathiae* had entirely disappeared but the arthritis agent was readily isolated from the tissue of the 2 pigs at this time. Thus, the arthritis agent does not resemble the virus isolated by Köber,[5] who found it associated with swine erysipelas and also found that each assisted the other to produce disease.

To date, only pigs of from 75 to 140 days of age have been employed in inoculation experiments. All have been susceptible. Recovery from one injection apparently renders pigs solidly immune to subsequent exposure. Passage of the arthritis agent through chicken embryos for a few months seems to greatly attenuate it for swine. Thus, it seems that one could develop a satisfactory live vaccine from embryo-propagated material.

The active agent has been recovered one or more times from the lymph glands, spleen, pleural exudate, peritoneal exudate, joint exudate, blood, and urine of experimentally infected pigs. In testing such organs as the lymph glands, liver, kidneys, etc., for the presence of the agent, it is necessary to suspend ground portions of the organs in some fluid such as physiological salt solution, or salt solution mixed with serum, in order to obtain suitable material for embryo injection. However, dilution should be avoided as much as possible because moderate dilution often caused material to test negatively although it tested positively when not diluted. Thus, abnormal joint fluids diluted as little as two or three times sometimes tested negatively. Of course, others diluted four to five times have been positive, but, to be sure that nothing is overlooked, the joint exudates and other fluid exudates should not be diluted at all if it can be avoided. These findings indicate that the agent is present in only very limited amounts in tissues or that large quantities are required for takes in embryos.

Material prepared for histological study has revealed nothing significant as to the character of the causal agent. This applies to sections from the affected joint capsules, inflamed serous membranes, infected chicken-yolk sacs, and infected embryos. Also, stained smears from inflamed articulations, infected embryos, membranes, etc., have shown nothing as to the causal agent. In preliminary trials, chicken-embryo material was passed through Berkefeld N filters and tested for the presence of the active agent. It was found that such filtrates contained only about 1 to 5 per cent of the active agent originally present in the material before filtration. The failure of the agent to pass filters in relatively large amounts does not prove it is not a virus, even though it is known that most of the common viruses would pass in large amounts under like conditions. The filtration experiments to date are inconclusive. The arthritis agent may or may not be a virus.

The arthritis agent resembles the causal agent of sporadic bovine encephalitis (McNutt and Waller,[6] McNutt[7]) in that it affects the joint capsules and the serous membranes and in that it is somewhat difficult to filter, (Stearns and McNutt[8]). In embryos infected with the arthritis agent there are no bodies in the lining epithelial cells of the yolk sac as seen in bovine encephalitis (McNutt and Stearns[9]), hence it is perhaps not related to the causal agent of the cattle disease.

At the present time, the authors have three other unidentified active agents in the laboratory. These were isolated by the authors and are known with reasonable certainty to be viruses. They are unidentified mainly because they all appear to be new, and hitherto undescribed. These were isolated from other herds. They are being compared to the arthritis agent. At present, it is impossible to say whether or not the arthritis agent has been isolated more than once.

In a few of our experimental pigs, it has been difficult to isolate the arthritis infection in the late stages of the disease. Good lesions might still remain but in some cases the agent seemed to have disappeared. It

is also possible that it was present in such low concentration as to render its identification almost impossible. This may account for failure to diagnose some field cases of peritonitis in the past. During the past several years, one of us (McNutt) has been called on twice to examine hogs dying of what appeared to be an aseptic peritonitis. There were large, winter losses of late summer and fall pigs in each instance. The lesions were severe peritonitis associated with much cheesy exudate and some fluid and adhesions. The symptoms were identical with those seen in our experimental hogs. No infection whatever was demonstrated in either instance, but an unidentified virus has since been isolated from 1 of these herds.

CONCLUSIONS

1) An apparently new pathogen for hogs is reported. It is described in so far as possible at the present time.

2) This active agent caused arthritis in field cases from which it was isolated.

3) In artificially exposed pigs, the agent produced arthritis, peritonitis, pleurisy, and pericarditis.

4) It has been compared in a superficial way to several known viruses, especially swine-influenza virus, and no relationship found. In fact, it is not known to be a virus.

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The Colostrum Pregnancy Test in Cattle

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IN 1940, Falls, Freda, and Cohen[1] reported a technique for an intradermal pregnancy test in women, using colostrum as an antigen. Since there would be many advantages in such a test on animals, the following work was undertaken to determine the reaction of a similar antigen in dairy cattle. Pregnant women show little or no reaction to the material, whereas nonpregnant women react rather vigorously, showing a characteristic wheal surrounded by a reddened area. The reaction in nonpregnant women is explained on the basis that they have become sensitized to a protein produced by the mammary gland at the time of puberty. It is assumed that during pregnancy enough of this protein is absorbed from the mammary glands to produce an immune state so that the local reaction is prevented.

PROCEDURE

Preparation of Antigen.—In women, the antigen is prepared by extracting colostrum from the breasts at about the seventh month of their first pregnancy. Antigens made at other times during the first or subsequent pregnancies were found to be less efficient. This material is more viscous and clearer than postpartum bovine colostrum, and should not be confused with it. The material is diluted with an equal volume of sterile normal saline solution, and filtered through a Berkefeld filter. Originally 0.1 cc. of a 1 per cent solution of merthiolate was added to each 10 cc. of antigen as a preservative. This was discontinued because of mercury reactions in some women.

The bovine antigen was prepared in the same manner, collecting it from first-calf heifers between five and eight and a half months pregnant. In all cases 0.1 cc. of a 1 per cent solution of merthiolate was added to each 10 cc. of antigen.

In all, 12 collections were made from 6 donors as indicated in table 1.

TABLE 1

ANTIGEN	DONOR	MONTH OF PREGNANCY
A	C424	6.75
B	C424	7.5
C	A32	6.0
D	A35	6.5
E	A35	8.0
F	412	5.5
G	A32	8.5
H*	A33	6.0
I	412	6.75
J†	....	....
K	A33	8.25
L	128	5.00

*Antigen H was used only in making up Antigen J.
†Antigen J consisted of equal parts of E, F, G, H, I.

Technique of Injection.—Several problems immediately presented themselves. Among them were the hair, the pigment, the thick bovine skin, and the difficulty of determining the optimum quantity and dilution of the antigen. It was first thought that clipping the short hair from the lateral surface of the udder would provide a suitable site for injection, as this area is frequently lighter colored, and the skin is relatively thin. However, certain objections were obvious after a few trials: Slight hemorrhage interfered with reading the test; the injection was rather difficult to make, and reddening was frequently difficult to see even in light colored cows. For these reasons, a new site was sought. It was believed that a point 6 to 8 mm. lateral to the mucocutaneous junction of the vulva and the skin would allow the injection to be made intradermally and still allow the reddening to spread over the normally pink vulvar mucosa. After trial, it was decided that the injection could be made into the mucosa just as easily. The standard site was about 6 to 12 mm. inside the vulvar orifice. The vulva was washed

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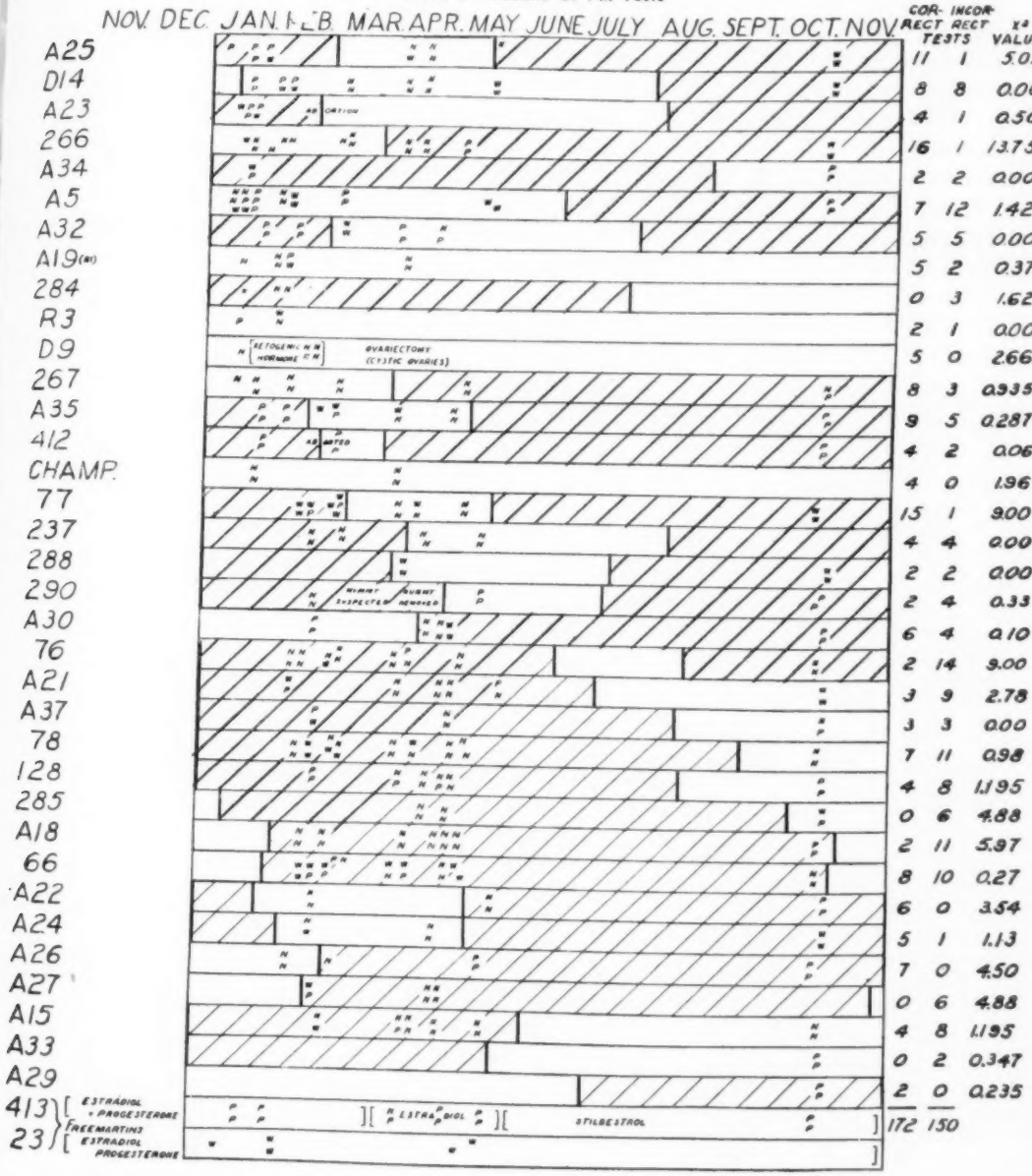
with 70 per cent alcohol or physiological saline and anesthetized with 1 per cent cocaine or 1 per cent butyn sprayed on with an atomizer.

The injection was made as near the surface as possible, using an intradermal syringe and a 25-gauge needle. A control injection consisting of physiological saline solution with merthiolate was made in each animal at a point about 4 cm. dorsal or ventral to the site of the antigen injection. Amounts injected were either 0.0625 cc., 0.125 cc., or 0.25 cc. The majority of the injections were 0.125 cc., because the

Chart 1—Results of All Tests



Individual cows are indicated by numbers on the left.

Pregnancy in each cow is indicated by crosshatching.

N = nonpregnancy reaction. P = pregnancy reaction. W = weak pregnancy reaction.

smaller amount was difficult to see, and it was felt that the larger amount might contain too much antigen or cause excessive local trauma. Various dilutions of the antigen were tried. In addition to the 1:1 dilution (see method of preparation), the following dilutions were used: 1:3, 1:7, 1:15.

Criteria Used.—In the nonpregnant woman, the wheal formed by the injection of the antigen increases in size and an areola, pink to red in color, develops around it in about thirty minutes. The absence of such changes indicates pregnancy. In the cow, the same criteria were used, bearing in mind that the vulvar mucosa is normally pink in color.

Readings were made at ten, thirty, and sixty minutes and the results recorded as "pale, slightly red, red and swollen, etc." These observations, when compared with the control, were then placed in one of three categories, pregnant, nonpregnant, or weak pregnancy. In the final handling of the data, the weak pregnancy readings were grouped with the pregnancy readings. This means that unless an easily recognized reddening or swelling developed, the cow was considered to test pregnant.

RESULTS

In all, 322 tests on 35 cows and 17 tests on 2 freemartins were made. All animals were a part of the experimental dairy herd, but, with the exception of 2 freemartins noted later, none was on an experiment which could be considered to affect the results of this work.

After sufficient time was allowed for each pregnant animal to deliver a calf, the accuracy of each injection as an indication of

TABLE 2—Results Obtained with Individual Antigens

ANTIGEN	AMOUNT IN CC.	DILUTION OF ORIGINAL MATERIAL	CORRECT PREGNANCY TESTS	INCORRECT PREGNANCY TESTS	CORRECT NONPREGNANCY TESTS	INCORRECT NONPREGNANCY TESTS	TOTAL CORRECT	TOTAL INCORRECT	χ^2 VALUES	TOTAL CORRECT FOR ANTIGEN	TOTAL INCORRECT	χ^2 VALUES
A	0.125	1:1	2	3	4	1	6	4	0.00			
	0.0625	1:1	6	2	5	3	11	5	0.95	17	9	1.01
B	0.0625	1:1	2	2	0	3	2	5	0.89	2	5	0.89
C	0.25	1:1	1	2	2	1	3	3	0.00			
	0.125	1:1	12	6	11	3	23	9	3.66			
	0.0625	1:1	0	1	0	0	0	1	0.00	26	13	2.28
D	0.25	1:1	0	0	1	0	1	0	0.00			
	0.125	1:1	8	7	10	4	18	11	0.06			
	0.0625	1:1	10	6	3	4	13	10	0.007	32	21	0.08
E	0.125	1:1	1	2	3	2	4	4	0.00	4	4	0.00
F	0.125	1:1	1	4	2	4	3	8	2.05			
	0.125	1:3	2	4	2	3	4	7	0.69			
	0.125	1:15	2	0	1	3	3	3	0.00			
	0.0625	1:15	1	0	0	1	1	1	0.00	11	19	2.72
G	0 125	1:7	0	0	1	5	1	5	2.54			
	0.125	1:15	1	3	3	1	4	4	0.00	5	9	1.16
I	0.125	1:7	0	1	1	7	1	8	4.90	1	8	4.90
J	0.125	1:1	0	1	6	6	6	7	0.06			
	0.125	1:3	1	0	8	8	9	8	0.02			
	0.125	1:7	6	5	10	16	16	21	1.17			
	0.125	1:15	11	5	6	9	17	14	0.00			
	0.0625	1:1	0	1	1	0	1	1	0.00	49	51	0.61
K	0.125	1:15	16	6	2	2	18	8	1.94	18	8	1.94
L	0.125	1:15	7	3	0	0	7	3	0.54	7	3	0.54
Totals	....	....	..	..	..	..	..	..	...	172	150	...

the absence or presence of pregnancy was determined. It is possible, of course, that some of the cows found to be nonpregnant were pregnant at the time of this test and later aborted or resorbed their fetuses. All cows were observed for about a year after the last tests so that pregnancy could be figured back from calving rather than from breeding dates and disappearance of heat periods. As our herd is under close management, abortions would be reported.

It was assumed that it would take a month following conception for the test to become positive for pregnancy. This choice was made on the basis of experience with pregnancy tests in general, in which it is found that about one month is necessary for detectable changes to develop. Also, it was assumed that the test should become negative for pregnancy at the time of parturition. Both of these assumptions may be unjustified.

The data obtained from the freemartins, summarized later, are not included in the general tabulations. The results of all tests are presented in chart 1. Total correct and incorrect tests are indicated at the right of the chart, along with chi-square values. The chi-square test was applied to determine whether there was a significant difference between the correct and incorrect tests in each cow and the total right and wrong tests in all cows.* A chi-square value of 3.84 or greater indicates that the probability of obtaining a particular combination of right and wrong tests, due to chance alone, is 5 per cent or less.

DISCUSSION OF RESULTS

Tabulation of the correct and the incorrect tests shows that, while for the entire group the test does not have a clinically significant accuracy, some individual cows show a statistically significant difference in their responses, even though it was necessary, due to smallness of the samples, to group together all tests in each cow. Examples of this are cow A25 with 11 correct tests, 1 incorrect, and a chi-square value of 5.03; cow 266 with 16 correct tests, 1 incorrect, and a chi-square value of 13.75; and cow 77 with 15 correct tests, 1 incorrect, and a chi-square value of 9.00. At the same time, others, such as 76, 285, A18, and A27 show significant differences in the opposite direction (more incorrect than correct).

Table 2 shows the results obtained with each antigen. It will be noted that certain of the antigens (such as 0.125 cc. of a 1:1 dilution of C, and 0.125 cc. of a 1:7 dilution of I) show a significant difference from chance reactions, but none was sufficiently accurate to be used as a pregnancy test.

A summary of results obtained with varying quantities and dilutions of antigen is shown in table 3. The only combination showing a significant difference from the totals is 0.125 cc. of a 1:7 dilution. This difference is in the direction opposite to the expected one, and appears to be due to a tendency of three antigens (G, I, and J) in this group to produce a large percentage of reactions (reddening) regardless of the presence or absence of pregnancy.

It is possible that one injection may affect subsequent ones made in the same period. For this reason an analysis was made of the first tests in each pregnancy or nonpregnancy period. It was assumed, as mentioned previously, that the test should change from nonpregnancy to pregnancy about one month after breeding and from pregnancy to nonpregnacy at parturition. On this basis, there are 39 correct diagnoses and 25 incorrect ones. This distribution shows a chi-square value of 1.44, which is higher than many of those from tables 2 and 3, but not significant. By omitting the tests made within thirty days after parturition (at which time the test would not be employed) there are 35 correct and 18 incorrect tests. The chi-square value is 2.4,

*The formula[2, 3] used for calculating these values follows:

$$\text{chi-square} = (d-0.5)^2 \sum\left(\frac{1}{m}\right)$$

where: d = the difference between the observed values and the expected values (calculated on the basis of the total right and wrong tests).

0.5 = Yates correction for continuity[3].

$\sum\left(\frac{1}{m}\right)$ = the sum of the reciprocals of the calculated values.

TABLE 3—Effect of Amount and Dilution of Antigen upon the Test

Amount Injected (cc.)	Dilution	Correct Pregnancy Tests	Incorrect Pregnancy Tests	Correct Nonpregnancy Tests	Incorrect Nonpregnancy Tests	Total Correct	Total Incorrect	χ^2 Values
0.25	1:1	1	2	3	1	4	3	0.000
0.125	1:1	24	23	36	20	60	43	0.79
0.125	1:3	3	4	10	11	13	15	0.324
0.125	1:7	6	6	12	28	18	34	6.68
0.125	1:15	37	17	12	15	49	32	1.34
				Totals for 0.125 cc.		140	124	0.004
0.0625	1:1	18	12	9	10	27	22	0.007
0.0625	1:15	1	0	0	1	1	1	0.000
				Totals for 0.0625 cc.		28	23	0.007
Totals		90	64	82	86	172	150	....
All 1:1 dilutions		43	37	48	31	91	68	0.822

which is more favorable than the one above, but still not statistically significant.

The Freemartins.—From chart 1 it will be noted that 1 freemartin (413), with only one exception, gave a positive pregnancy test. The other (23) gave nothing but weak-pregnancy reactions. Both these animals were receiving sex hormones preceding, at the time of, and following the tests. Cow 413 received estradiol and progesterone between November 1 and March 30, estradiol only from April 1 to May 30, and stilbestrol from June 1 to January 10. Cow 23 received estradiol and progesterone between November 1 and the next November 1. It seems probable that these hormones caused reactions that simulated pregnancy to a sufficient extent to give positive pregnancy tests.

SUMMARY

The results of 322 colostrum injections into 35 cows and 17 into 2 freemartins are presented. Analysis from the standpoints of the response of individual cows, the antigen used, the amount injected, and the dilution used indicates that while there appear to be marked differences in the responses of some animals to certain antigens, the test is not of sufficient accuracy in the bovine species to be used as a pregnancy test. It appears that the variations in responses to the test were due, not so much to the differences between antigens, dilutions, and the amounts injected, as to differences between the individual cows. In other words, whereas no one antigen, dilution, or amount injected gave a high percentage of correct tests, certain individual cows responded with an accuracy of better than 90 per cent.

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The Effect of Low Outdoor Temperatures on the Free-Living Stages of Some Common Nematode Parasites of Sheep

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SEVERAL investigators[1, 2, 3, 4] have shown that the preparasitic stages of Ostertagia spp., Nematodirus spp., and *Trichuris ovis* survived over winter on pastures at Beltsville, Md., and in eastern Canada in fairly high proportions; those of *Haemonchus contortus* and Trichostrongylus spp. survived in smaller proportions, and those of *Oesophagostomum columbianum, Cooperia curticei,* and *Bunostomum trigonocephalum* did not survive at all. In contrast to these findings, Baker[5] reported that the preparasitic stages of all these nematodes survived at least one year on a pasture in New York. In these experiments the infected animals were usually removed in the fall from the pastures which were then unoccupied during the winter. Survival of the parasites was determined by the infection acquired by parasite-free lambs grazing on the pastures during the next spring. The results of these experiments are of considerable practical value, because they can be used directly in assessing the danger of nematode infection to sheep and lambs turned onto the pasture in spring, but they fail to give information on the fate of nematode eggs deposited on the pasture during the winter in those cases in which sheep are permitted to run on the pasture throughout the winter.

The following experiments were undertaken to determine the effect of outdoor exposure during the colder months on the possible survival and development to infective larvae of the common roundworm parasites of sheep, *C. curticei,* Trichostrongylus spp., *Oe. columbianum,* and *Ostertagia circumcincta.* Since previous work[6] had shown that outdoor temperatures, not moisture conditions, were the limiting factor in the survival of preparasitic stages of *H. contortus,* at mean maximum temperatures below 65 F., the present experiments were expressly designed to study the effect of exposure to low temperatures. The work was performed at the United States Department of Agriculture Research Center, Beltsville, Md.

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MATERIALS AND METHODS

Experiments with eggs of *C. curticei, Oe. columbianum* and *Os. circumcincta* were conducted from December, 1941 to April, 1942 and from October, 1942 to April 1943. In addition, experiments with the eggs of Trichostrongylus spp. were conducted during the second period. The parasite eggs used in these experiments were obtained from 4 rams, in each of which an experimental infection with only 1 of the parasites mentioned was maintained. During the course of the experiments the animals were kept in separate pens; feces were collected from them by means of a cloth bag and harness for twenty-four hours preceding the beginning of an experiment. The feces were then crushed in a mortar and stirred, and several 50 Gm. samples were weighed out and placed in glass jars. Some samples were set outdoors in a low wooden shelter resting on the ground, open only to the north, and having a wide roof to protect the feces from rain, snow, and direct sunlight. The samples were left outdoors for about fourteen days, since in preliminary outdoor experiments under favorable conditions, no more infective larvae were produced in three or four weeks than in two weeks from similar numbers of eggs. Control sample jars were covered with screw caps and set in a dark cupboard indoors until examined.

To determine whether the eggs had developed into infective larvae while outdoors, a dilution count was made on a portion of the feces at the end of the exposure period as well as on the control samples. Since the primary interest in these experiments was in the development of the eggs to live infective larvae, only such larvae, which were a majority, were counted. Where no infective larvae developed

outdoors, a portion of the feces was subsequently cultured indoors for a week and then examined for infective larvae. In the few exceptions to this procedure, noted in table 1, the entire sample was examined at the indicated time. The size of the portions examined was different in the two years. In the experiments conducted in 1941 to 1942, there were 2 samples exposed outdoors and 4 controls in each experiment; 25 Gm. of each exposed sample were examined shortly after exposure and the other 25 Gm. after indoor incubation. In the second year, when 4 samples were exposed outdoors and 2 were kept as controls in each experiment, the entire 50 Gm. sample was examined at one time.

Outdoor air and soil temperatures were measured with a distant recording thermometer having three leads, one of which was tied to the north side of a tree trunk 4 feet above the ground and 10 feet from the samples, another was covered with a thin layer of sandy soil, and the third lead was laid on the surface of a grass plot. The soil and grass plots were 5 feet from the samples, and were exposed to sunlight.

EXPERIMENTAL RESULTS

The data on the number of infective larvae found in the various experiments are presented in table 1.

To make the data comparable, the num-

TABLE 1—Number of Live Infective Larvae Developed from Various Parasite Eggs Exposed Outdoors

DATE EXPOSED	DAYS EXPOSED	AVERAGE AIR TEMPERATURE (F.) MAXIMUM	AVERAGE AIR TEMPERATURE (F.) MINIMUM	NO. OF EGGS/50 GM. OF FECES	NUMBER OF LIVE LARVAE/50 GM. OF FECES: CONTROLS	NUMBER OF LIVE LARVAE/50 GM. OF FECES: EXPOSED	NUMBER OF LIVE LARVAE/50 GM. OF FECES: EXPOSED AND CULTURED
Ostertagia circumcincta							
4/ 6/42	14	66	42	16,650	163	238	0
10/15/42	14	64	48	300	67	118	..*
10/29/42	13	61	38	1,000	134	167	..
11/11/42	13	57	34	2,500	799	234	100
3/16/42	15	53	35	1,050	113	0	25
12/16/41	13	51	31	13,300	1,550	0	700
2/17/43	14	49	23	450	0	0	..
12/ 8/41	14	47	26	10,000	1,325	0	1,150
1/ 9/42	14	42	19	2,250	1,075	0	25
1/ 5/43	14	41	26	750	83	0	137
12/23/42	16	40	28	1,800	116	0	235
2/11/42	14	40	19	1,950	1,025	0	250
11/27/42	12	39	24	2,100	416	0	100
1/20/43	14	37	23	450	17	0	33
2/ 4/43	13	36	20	250	0	0	0
12/10/42	13	31	14	2,250	500	0	0
Trichostrongylus spp.							
10/14/42	13	64	50	300	506	533	..
10/28/42	13	61	37	900	132	33	..
11/11/42	13	57	34	1,200	234	0	17
2/16/43	13	48	21	150	0	0	0
11/25/42	13	42	26	1,500	117	0	17
1/ 6/43	14	42	25	600	183	0	0
12/23/42	15	40	28	600	66	0	0
2/ 2/43	14	38	21	450	100	0	0
1/20/43	13	37	23	300	0	0	0
12/ 9/42	12	32	14	1,650	17	0	0
Cooperia curticei							
10/13/42	14	65	52	1,500	34	34	..
4/ 8/42	14	61	40	10,000	1,875	0	50
10/27/42	13	60	36	1,200	67	0	..
11/10/42	13	59	34	600	50	0	..
3/18/42	14	51	34	10,000	6,825	0	75
12/19/41	14	49	30	30,000	8,000	..	0
1/12/42	14	49	26	16,600	2,475	0	0
12/ 5/41	14	47	28	36,600	11,300	0	0
11/24/42	13	43	27	900	33	0	0
2/16/42	14	41	21	7,500	10,400	0	0
12/ 7/42	14	33	16	1,200	33	0	0
Oesophagostomum columbianum							
10/16/42	14	65	46	14,400	1,583	25	..
4/10/42	14	63	40	9,300	232	0	0
10/30/42	13	60	38	6,700	1,415	0	..
11/13/42	14	58	35	3,150	684	0	..
3/13/42	14	56	36	43,300	350	0	0
12/ 2/41	15	49	30	45,500	1,050	0	0
12/18/41	13	49	30	35,800	200	..	0
2/ 6/42	14	41	21	46,600	25	0	0
11/27/42	13	39	24	600	0	0	0
1/ 7/42	14	39	16	26,650	775	0	0
12/11/42	13	32	14	600	0	0	0

*No examination made.

ber of larvae found at each examination was first computed on a 50 Gm. basis, even though some samples in the first year were examined in 25 Gm. portions, and then averaged. These duplicate, and in some cases quadruplicate, determinations showed comparatively little variation in the same experiment.

The data in table 1 show that in some experiments, infective larvae were recovered immediately after exposure; in others, however, larvae were recovered only after indoor incubation, while in some tests, no larvae were recovered at either time. Where no infective larvae were recovered, it is not known from the available data whether the eggs or the preinfective larvae were killed by the exposure; these stages will be referred to throughout this paper as preinfective stages. By using the presence in cultures of live infective larvae as the measure of viability, the data in table 1 may be considered under four main categories, namely, preinfective stages that: (*a*) were killed during the 24-hour period of collecting the feces, as shown by the presence of eggs in the feces and the absence of larvae in the control cultures; (*b*) were killed during fourteen days exposure outdoors, as shown by the presence of larvae in the controls but none in the outdoor cultures, even after subsequent incubation; (*c*) survived exposure, as shown by the presence of larvae in the controls and in outdoor cultures only after incubation; (*d*) developed outdoors, as shown by the presence of infective larvae in the outdoor cultures directly after exposure. In a supplementary group (*e*) are included results of four experiments in which no larvae were found directly after exposure, but in which no subsequent indoor cultures were made. All that can be said of this group is that the eggs did not develop outdoors. Whether any preinfective stages survived can only be conjectured from the

TABLE 2—Survival and Development of Preinfective Stages During Exposure of About Fourteen Days to Indicated Mean Maximum and Minimum Outdoor Temperatures

Eggs of:	Mean Min. Temp. (F.)	Mean Maximum Temperature (F.)							
		30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69
Ostertagia circumcincta	10-14	B							
	15-19			C, C					
	20-24		A, C, C		A				
	25-29			C, C	C				
	30-34					C	D		
	35-39					C		D	
	40-44								D
	45-49							D	
Trichostrongylus spp.	10-14	B							
	15-19								
	20-24		A, B		A				
	25-29			B, B, C					
	30-34						C		
	35-39							D	
	40-49								
	50-54							D	
Cooperia curticei	15-19	B							
	20-24			B					
	25-29			B	B, B				
	30-34				B	C	E		
	35-39							E	
	40-44							C	
	45-49								
	50-54								D
Oesophagostomum columbianum	10-14	A							
	15-19		B						
	20-24		A	B					
	25-29								
	30-34				B, B				
	35-39						B, E	E	
	40-44							B	
	45-49								D

A = Preinfective stages killed during 24-hour collection.
B = Preinfective stages killed during outdoor exposure.
C = Preinfective stages survived outdoor exposure.
D = Preinfective stages developed during outdoor exposure.
E = Preinfective stages did not develop during outdoor exposure.
Each letter refers to an experiment.

results of other experiments at similar temperatures. A comparison of the results of experiments with the four parasites, classified and designated by the letters in parentheses, is presented in table 2.

Since the data in table 2 show that the 4 species of parasites varied in their resistance to exposure, the various parasites will be discussed in order of increasing resistance. Also since the experiments were grouped in temperature intervals of 5 F. in table 2, the maximum and minimum temperatures for each experiment in the following discussion were obtained from table 1.

Considering the lethal temperatures first, the preinfective stages of Oesophagostomum were killed during fourteen days exposure to mean maximum temperatures ranging from 63 to 32 F. and mean minima from 40 to 14 F. in 6 out of 10 experiments in this group. In 2 other experiments they were killed during the collection period when the temperatures ranged from 63 to 32 F. and 38 to 22 F., respectively. The preinfective stages of Cooperia were killed outdoors in all 6 experiments in which the mean maxima ranged from 49 to 33 F. and the minima, from 30 to 16 F.; those of Trichostrongylus were killed outdoors in 4 out of 6 experiments in which the maxima ranged from 42 to 32 F. and the minima, from 28 to 14 F. In the fifth experiment in this group, the preinfective stages were killed during collection, when the temperature ranged from 46 to 9 F., but in the sixth, they survived the fourteen day exposure and yielded a few infective larvae on subsequent culture. In the only other experiment where Trichostrongylus preinfective stages were killed during collection, the temperature ranged from 12 to -3 F. The preinfective stages of Ostertagia were killed outdoors in one experiment when the mean maximum temperature was 31 F. and the minimum, 14 F. In 2 other experiments in which the preinfective stages were killed during collection, the temperatures for the twenty-four hours ranged from 36 to 16 F. and 20 to -3 F., respectively. It is to be noted that the temperatures during the collection period were taken in the open air, and are given only as an approximate indication of the temperatures in the cloth bag which were affected by the body heat of the sheep and by the protection afforded by the closed shelter in the outdoor pen. From this survey of lethal temperatures, it is evident that the preinfective stages of all 4 parasites would be killed by exposure for fourteen days to mean maximum temperatures of 31 F. and lower and minima of 14 F. and lower. If the single experiment in which Ostertagia preinfective stages were killed during fourteen days outdoors is set aside, then the common lethal temperature limits for Trichostrongylus, Cooperia and Oesophagostomum become maxima below 42 F. and minima below 29 F.

There are only a few experiments with all 4 parasites in which the preinfective stages survived outdoors without developing into infective larvae. Because of this comparatively small number and the wide range of temperatures involved, it is not possible with the present data to designate any common temperature range favorable for survival. However, it is worth noting that the preinfective stages of Ostertagia survived at temperatures which in most experiments proved lethal to the other 3 parasites.

Finally, the eggs of Ostertagia developed into infective larvae during fourteen days outdoors at mean maxima of 57, 61, 64, and 66 F. in 4 experiments, while those of Trichostrongylus developed at maxima of 61 and 64 F.; those of *Cooperia* at 65 F.; and those of Oesophagostomum in 1 experiment at 65 F. It is probable that the eggs of all 4 parasites would develop at mean maxima of about 65 F. or higher.

The relative hardiness of the preinfective stages of the 4 species can be measured by a comparison of the total number of larvae which developed in the outdoor cultures either during exposure or after subsequent indoor incubation, with the total number of larvae in the controls. For this purpose, the data from those experiments falling into groups B, C, D were used. In group B, no larvae were recovered from the outdoor cultures, so only the

totals in the controls are given. In group C, the total number of larvae found in the cultures after incubation was divided by the total number in their controls, while in group D the total found directly after exposure was divided by the total in their controls. These percentages, along with the total number of larvae in the controls, are presented for each parasite in table 3. The 4 inconclusive experiments, group E, with Cooperia and Oesophagostomum eggs were omitted from this table.

The data in table 3, based on a small number of experiments which were not performed under identical conditions, are not strictly comparable. Nevertheless they do indicate a contrast in hardiness between the preinfective stages of Ostertagia and those of the other parasites. The very high percentage of development of the eggs of Trichostrongylus, the result of a higher number of larvae in the exposed cultures than in the controls in 1 out of 2 experiments in this group, as well as the single experiment with Cooperia eggs, with 34 larvae in both control and exposed cultures, are probably exceptional.

TABLE 3—Resistance to Low Temperatures of Preinfective Stages of Four Species of Nematodes Parasitic in Sheep

Eggs of	Response of Preinfective Stages to Outdoor Exposure: Killed — Total Larvae in Controls (No.)	Killed — Larvae from Exposed Cultures (% of Controls)	Survived — Total Larvae in Controls (No.)	Survived — Larvae from Exposed Cultures (% of Controls)	Developed — Total Larvae in Controls (No.)	Developed — Larvae from Exposed Cultures (% of Controls)
Ostertagia	500	0	5,720	46	1,163	65
Trichostrongylus	366	0	351	10	632* (132)†	90 (25)
Cooperia	32,241	0	8,700	1	34	100
Oesophagostomum	2,632	0	0	0	1,583	2

*Data for the 2 experiments in this group, including 1 with very high proportion of larvae developed outdoors.
†Data for only 1 experiment with lower proportion of larvae developed outdoors.

As a check on the correspondence between the air temperatures presented here and those prevailing near the ground surface, computations of the mean maximum and minimum temperatures in the air and shade, those immediately under the surface of bare soil in the sun and those at the soil surface of grass sod were made from the thermograph records for the months during which experiments were conducted. The maximum difference among these temperatures occurred in February, 1942 when the air minimum was 19 F., and the soil and sod minima 28 and 27 F., respectively. In general, the deviations from the mean monthly air temperatures averaged about 4 F., except for the April temperatures, when the sun had begun to heat the soil and sod more than in the previous months. In addition, other measurements indicate that temperatures immediately under the surface of bare soil in the shade approximated closely those in the air. However, these temperature comparisons should be applied cautiously to different regions, because many local differences, such as location, soil type, exposures, plant cover, and especially amount and persistence of snow would affect these temperature differences. For example, Mail[7] has shown that in Minnesota a prolonged cover of snow insulates the soil against colder air temperatures.

DISCUSSION

Since the present experiments were primarily concerned with determining the po-

tential danger to sheep of infection from parasite eggs exposed to low outdoor temperatures, the development of infective larvae from the eggs was used as a measure of such danger. No infective larvae were obtained from eggs of Cooperia, Trichostrongylus (with one exception), and Oesophagostomum when the mean maximum temperatures during about fourteen days exposure fell below 42 F. and the mean minima below 29 F. Hence if sheep infected with these parasites were removed from pasture before or during the occurrence of such low temperatures, the recently deposited preinfective stages would probably be killed in two weeks. On the other hand, if infected sheep were maintained on the same pasture throughout the winter, a continuous supply of eggs would be deposited on the pasture. Under unfavorable conditions, the eggs present on the pasture would be killed; however, other eggs would be deposited and be available to develop to infective larvae at the earliest favorable opportunity. Therefore, by the following spring, the potential danger of infection of sheep and lambs with these parasites would depend in part upon the management of the pasture during the winter. This does not take account of infective larvae which developed during favorable periods while the sheep were on pasture and which survived over winter. This possibility, of course, may constitute an additional reservoir of infective larvae, and is the subject of another study.

The foregoing considerations apply also to the eggs of Ostertagia, except that the preinfective stages survived at some low temperatures which killed the other 3 parasites discussed in this paper. Additional evidence of the greater resistance of Ostertagia is shown by the data in table 3, namely, that much higher percentages of Ostertagia eggs survived or developed to infective larvae outdoors than did the eggs of the other 3 species. The data on the percentage of viability of the eggs apply only to relatively low temperatures, and give no information with respect to development under optimum conditions.

While the emphasis here has been on temperature limits, rather than on seasons, it is the seasons during which such low temperatures prevail that are of practical concern. Although it is not possible to predict when the mean maximum temperature will fall below 50 F. for fourteen days, under the climatic conditions of Beltsville, Md., it is safe to say that such periods would most probably occur during December, January, and February, and occasionally in late November and early March. For other localities with different climates, this temperature zone may cover a longer or shorter period, and should be determined locally.

SUMMARY AND CONCLUSIONS

1) Eggs of *Cooperia curticei*, *Oesophagostomum columbianum* and *Ostertagia circumcincta* were exposed outdoors for intervals of about fourteen days during December, 1941 to April, 1942 and October, 1942 to April, 1943, at Beltsville, Md., while those of Trichostrongylus spp. were exposed in the second period only.

2) The preinfective stages of Oesophagostomum were killed by outdoor exposure to comparatively high temperatures; those of Ostertagia survived all but the very low temperatures. The temperatures lethal to the preinfective stages of Oesophagostomum, Cooperia and Trichostrongylus were mean air maxima for fourteen days below 42 F. and minima below 29 F.

3) Some eggs of Ostertagia developed into infective larvae during exposure to mean maximum air temperatures of 57 F.; of Trichostrongylus, to 61 F.; of Cooperia and Oesophagostomum, to 65 F.

4) In those experiments in which infective larvae were obtained only after indoor culture following exposure, the exposed Ostertagia cultures yielded 46 per cent as many larvae as found in control cultures; the Trichostrongylus cultures, 10 per cent; the Cooperia cultures, 1 per cent, and the Oesophagostomum cultures, 0 per cent.

5) In those experiments in which the infective larvae developed outdoors, the exposed Ostertagia cultures yielded 65 per cent as many larvae as the controls; the

Trichostrongylus cultures, 90 per cent; the Cooperia cultures, 100 per cent; and the Oesophagostomum cultures, 1 per cent. The high yield of Trichostrongylus is the result of a higher number of larvae in the exposed than in the control cultures in 1 of 2 experiments in this group; that of Cooperia, of 34 larvae in both control and outdoor cultures.

6) The preinfective stages of Cooperia, Trichostrongylus, and Oesophagostomum exposed on pastures to climatic conditions similar to those of Beltsville, Md., would probably be killed during the months of December, January, and February, while those of Ostertagia would probably be killed only by sustained temperatures below freezing. Also the eggs of Ostertagia would survive and begin to develop at lower temperatures than the eggs of the other 3 parasites.

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Corrigendum

The July 1945 issue: page 198, third paragraph, fourteenth line, should read "virus is necessary for the production."

In table 2 under "Results": the last 3 lines should appear below the last line of the table under "12 control birds." The 3 lines under "Results" reading: "3 males and 5 females died with some form of leucosis" should appear in the space occupied by the 3 lines moved to below the line of the table.

In table 5 in the Z series "3 of 30 vaccinated birds" should read "8 of 30 vaccinated birds."

Salmonella Types Isolated from Snakes

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SINCE THE writers[1, 2] first called attention to the fact that snakes may act as reservoirs for Salmonella, surveys have resulted in additional isolations. It is the purpose of this paper to record these isolations and to present a check-list of Salmonella isolated from snakes (table 1). These studies have been made in an effort to locate animal reservoirs that might account for hitherto unexplained outbreaks of salmonellosis in turkeys.

METHODS

A total of 41 snakes from five localities in southern California and two localities in northern California were caught by the writers or were submitted to them by coöperators. In addition to the ones from these localities, 14 snakes from the reptile exhibit of the San Diego Zoo have been examined, making a total of 55 examined from May 1943 to January 1945. The list from the field contains the following types: 28 gopher snakes, 4 garter snakes, 4 racers, 4 king snakes, and 1 rattlesnake. The Zoo list contains 3 gopher snakes, 9 rattlesnakes and 2 exotic types.

Live snakes were killed by chloroform inhalation just before necropsy, and an effort was made to keep each organ separate for bacteriological examination. Tissues for bacteriological study were enriched in tetrathionate broth (Difco) to which was added 1-50,000 brilliant green. Seedings from t.t.b. were made on one or more of several mediums now in use for Salmonella isolation, but desoxycholate agar (B.B.L.) was most often used. Identification of the cultures as Salmonella was made by the standard technique. Final types were determined by antigenic analysis according to the Kauffmann-White Schema by the method described by Edwards and Bruner[3] with typing serums furnished by the U. S. Army Medical School. At least one culture from each specimen was also submitted to Dr. P. R. Edwards, National Salmonella Center, Lexington, Ky., who verified our results.

RESULTS

A total of 11 (26.8%) of the 41 snakes caught in their normal environment yielded Salmonella from one or more tissues. Of the 14 snakes from the San Diego Zoo, 1 yielded *Salmonella panama*. The list of Salmonella isolated is given in table 1. A brief summary of each new case is given below. It will be noted that *Salmonella meleagridis*, *Salmonella rubislaw*, and *S. panama* have each been isolated once from snakes. *Salmonella typhimurium* has been isolated twice, and *Salmonella newport* seven times.

CASE HISTORIES

The histories of the snakes which yielded *S. meleagridis* and *S. typhimurium* have been described in our previous papers.[1, 2]

257/36.—This male adult garter snake (*Thamnophis hammondii*) was caught in a turkey-poult yard in June 1944, on the same ranch where one of the snakes yielding *S. typhimurium* was caught.[2] *S. newport* was isolated from its kidneys and testes. It appeared to be normal when caught and no macroscopic lesions were noted on autopsy. *S. newport* caused severe losses in one brood of poults on this ranch during the spring of 1942. The survivors of that outbreak were tested several times until a nonreacting flock was obtained, and no other outbreak of *S. newport* infection in poults has been diagnosed on this ranch since 1942. One can only speculate as to the original source of the organism on this ranch.

256/28, 29, 30.—On May 18, 1944, three apparently healthy gopher snakes (*Pituophis catenifer deserticola*) were brought to the laboratory from the turkey ranch from which the *S. meleagridis* case came in 1943.[1] They had been caught near a barn where turkey feed was stored. Of the three, *1* was a mature male, *1* a mature female, and the third a young male. Except for a slight amount of amber fluid in the abdominal cavity of the female, they appeared normal on necropsy. *S. newport* was isolated from the kidneys and intestine of the male; from the ovaries of the female; and from the liver of the young snake.

From 1 lot of poults hatched on this ranch six days later (May 24), *S. newport* was also isolated. At one week, the mortality in these poults was 50 per cent. This was the first season that this type had appeared on this ranch. Again one can only speculate on how and when it was first introduced. Since gopher snakes eat rodents, it is possible that mice, brought in with the feed, may have been re-

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sponsible. It is also possible that it may have been introduced by human beings as a food-borne infection. There is considerable evidence that it had been recently introduced, since autopsy records on large numbers of poults from this ranch are available over a period of six years, and *S. newport* had not been previously isolated.

256/31.—About three weeks after the snakes referred to above were submitted (June 6), another normal mature male gopher snake was caught in the same area on the same ranch. *S. newport* was isolated from its kidneys and intestine.

256/55, 58.—These snakes, both adult gopher snakes, were two of a shipment of six received on Sept. 1, 1944, from the same ranch. Both yielded nonmotile organisms which were typical biochemically of the Salmonella. Antigenically they had "0" antigens like *S. newport*, but could not be typed specifically because of lack of "H" components. From 1 of these, the same nonmotile type was isolated from the heart blood, liver, and intestine and from the heart blood, liver, and lungs of the other. Subsequently by serial passage of these "nonmotile" strains through semisolid gelatin agar, one strain from each (lung of 55, and heart blood of 58) became motile. The "H" antigens of these were identical to *S. newport*, so it can be reasonably assumed that the rest are nonmotile variants of this type.

The other four snakes in the shipment failed to yield Salmonella types.

3459/1.—On May 5, 1944, a gopher snake (*Pituophis catenifer catenifer*) was found in the feed room at the Poultry Division farm on the University campus at Davis. From the intestine of this snake, *S. rubislaw* was isolated. This type has been reported in turkeys,[4] but it had not been isolated previously from any animals from this farm, nor has it been isolated since then.

270/44.—On Oct. 1, 1944, a Cuban snake (*Alsophis angulifer*) died in the San Diego Zoo. At necropsy we found the liver and kidneys markedly congested, and the snake was in poor flesh. From the heart blood, liver, testes, lungs, and kidneys of this snake, *S. panama* was isolated. The snake had been in the Zoo since 1939. *S. panama* has been found in human beings, in chicks, and in poults from this area, but from no other animals from the Zoo. Its source in the snake is not known.

DISCUSSION

Our attention was first called to the possibility of snakes acting as another reservoir of Salmonella, when *S. meleagridis* was isolated from a gopher snake caught on a ranch where this Salmonella type was causing losses in turkey poults[1]. The ranch where this snake was caught is located on the Mohave Desert. The owner has ex-

TABLE 1—Check-List of Salmonella Types Isolated from Snakes

ACCESSION NUMBER	HOST	SALMONELLA TYPE ISOLATED	TISSUES FROM WHICH ISOLATED
174/18	gopher snake (*Pituophis catenifer deserticola*)	*Salmonella meleagridis*	Liver.
257/33	gopher snake *Pituophis catenifer annectens*	*Salmo . . typhimurium*	Heart blood, liver, lungs, kidneys, ovaries, intestine.
293/10	garter snake (*Thamnophis hammondii*)	*Salmonella typhimurium*	Liver, spleen, testes, intestine.
257/36	garter snake (*Thamnophis hammondii*)	*Salmonella newport*	Kidneys, testes.
256/28	gopher snake *Pituophis catenifer deserticola*	*Salmonella newport*	Kidneys, intestine.
256/29	gopher snake *Pituophis catenifer deserticola*	*Salmonella newport*	Ovaries.
256/30	gopher snake *Pituophis catenifer deserticola*	*Salmonella newport*	Liver.
256/31	gopher snake *Pituophis catenifer deserticola*	*Salmonella newport*	Kidney, intestine.
256/55	gopher snake *Pituophis catenifer deserticola*	*Salmonella newport*	Heart blood, liver, intestine.
256/58	gopher snake *Pituophis catenifer deserticola*	*Salmonella newport*	Heart blood, liver, lungs.
3459/1	gopher snake *Pituophis catenifer catenifer*	*Salmonella rubislaw*	Intestine.
270/44	Cuban snake (*Alsophis angulifer*)	*Salmonella panama*	Heart blood, liver, testes, lungs, kidneys.

perienced severe losses from salmonellosis in his turkey poults over a period of several years, and a total of seven types have now been isolated from turkeys, chickens, and snakes from this ranch. Since the owner has his own hatchery; maintains his own breeding flocks; and does not introduce any outside stock, it has been difficult to explain the origin of the numerous Salmonella isolated.

A total of 25 of the 41 snakes caught in the field came from this ranch and seven of them yielded Salmonella. (174 and 256 series in table 1). The list of snakes from this ranch included 21 gopher snakes, 3 garter snakes, and 1 red racer. Rattlesnakes are found in that area, but none was killed on the ranch during the survey. During 1944, the owner carried out an intensive snake-eradication campaign, and it is of interest that for the first time in four years, no Salmonella reactors were found in his turkey breeders when they were tested in the fall of 1944.

Three of the 4 remaining snakes which yielded Salmonella came from 2 turkey ranches where unexplained outbreaks of salmonellosis had occurred. In each case, the types isolated were the same ones which had caused losses in turkeys on the ranches. *S. rubislaw*, isolated from the eleventh infected snake, has not caused losses on the ranch where the isolation was made, but it has been known to cause mortality in turkeys elsewhere. The types isolated from snakes have all been the cause of food poisoning outbreaks in man[4], and reptiles must now be added to the list of animal reservoirs for Salmonella.

It will be noted by an examination of the check-list (table 1) that with the exception of the "Cuban snake" from the Zoo, the infected ones were all gopher and garter snakes. This probably is not significant, since very few representatives of the other genera were submitted during the survey. The 1 rattlesnake came from a sheep and turkey ranch in northern California where, to the best of our knowledge, there have been no outbreaks of salmonellosis. Nine of the 14 zoo snakes were rattlesnakes, but no true Salmonella have been isolated from them. However, several strains of the Edwards, Cherry, and Bruner[5] paracolon types have been isolated from these rattlesnakes, as well as from several of the snakes found on ranches.

SUMMARY

1) A total of 11 (26.8%) of 41 snakes caught on ranches in seven localities yielded Salmonella. One (7.1%) of 14 snakes from zoo exhibits also yielded a Salmonella.

2) Five types have been isolated: *Salmonella meleagridis, Salmonella typhimurium, Salmonella newport, Salmonella rubislaw, and Salmonella panama.*

3) This relatively high incidence in snakes on ranches indicates that reptiles, like birds, may serve as important reservoirs of Salmonella. This might well have a public health significance.

4) These isolations again illustrate the wide range of host-parasite adaptation displayed by Salmonella.

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